RETENTION OF VERBAL INFORMATION BY APHASIC SUBJECTS

By

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To my best friends:

RJG

MLVR

RDR

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RETENTION OF VERBAL INFORMATION BY APHASIC SUBJECTS

By

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The present study was undertaken to determine whether a sample of persons with aphasia employed rehearsal as a strategy for maintaining verbally coded information in primary memory and whether the fluency of their verbal output correlated with the efficiency of their rehearsal.

In the experimental method employed in this investigation, the subjects were presented a set of stimuli to retain and a response delay was imposed during which time a distraction task was or was not presented. The subjects then reproduced the stimuli. Assuming that distraction interfered with efficient rehearsal, this procedure was used to examine rehearsal in aphasic individuals by comparing their performance when distracted to their performance when not distracted. Non-brain-damaged subjects and right-brain-damaged subjects were used as control groups. In addition, the aphasic subject group was divided into fluent aphasic and non-fluent aphasic groups for the purpose of comparing the performance of aphasic groups displaying qualitatively different verbal output.

Regarding differences in information processing between subject groups, it was found that aphasic subjects retained fewer items in all experimental conditions of this primary verbal memory task than did non-aphasic brain-damaged subjects (right brain-damaged subjects) or non-brain-damaged subjects. Also, aphasic subjects initially encoded significantly less information into the memory system than did non-aphasic subjects; right brain-damaged subjects initially encoded less information than normal subjects, followed by fluent aphasic subjects and non-fluent aphasic subjects respectively. In addition, the performance of the non-fluent aphasic group on the retention task was qualitatively different than the performance of the fluent aphasic subjects, right brain-damaged subjects, and non-brain-damaged subjects. It appeared as though these non-fluent aphasic subjects did not rehearse the verbal information while all other subject groups did. Therefore, not only do aphasic individuals process quantitatively less information than non-aphasic individuals on a verbal memory task, but non-fluent aphasic subjects also display qualitatively different information processing than fluent aphasic subjects or non-aphasic subjects.

CHAPTER I
INTRODUCTION AND REVIEW OF THE LITERATURE

Introduction

> Memory collects, organizes, preserves, and uses information for its own operations, which make up our gestures, verbal activities, decisions--that is, our general behavior . . . it has its successes, its difficulties, and its failures; it is the latter--since we take its successes for granted--that lead us to inquire into the workings of the component parts of its system. . . .
>
> (Barbizet, 1970, pp. 1-2)

Although the coordinated study of normal memory has spanned a century, little is known about disordered memory and its effect upon individuals who suffer from amnesia of some form. The quotation from Barbizet (1970) suggests that the memory system is the core from which all human behaviors, including "verbal activities," are generated, and that a dysfunction of "verbal activities" or any "human behavior" could be the direct result of a dysfunction of the memory system.

A number of aphasiologists have suggested a causal relationship between acquired language dysfunction and memory disorders. For example, Nielson (1936) suggests that " . . . agnosias and aphasias are all types of specific amnesias due to focal cerebral lesions" (p. 15). Martin (1974) states that aphasia results from a " . . . reduction in efficiency of the action and interaction of those cognitive processes which support language" (p. 80). Shallice and Warrington (1977) propose that in conduction aphasia " . . . a specific failure on repetition tasks exists which arises from a difficulty of auditory-verbal short-term memory" (p. 480). A causal relationship between cognitive processing dysfunction, specifically amnesia or memory disorder, and aphasia has yet to be experimentally established, however.

A coexistence hypothesis is one which proposes that primary memory for verbally encoded information is located in or near the area of the brain that processes language. Therefore, it would be expected that a high incidence of dysfunctions of primary memory for verbally coded information would occur with focal brain lesions resulting in aphasia. This hypothesis is supported by the findings of Milner (1962) in her lateralization studies.

Therapeutic Benefits of Information Concerning Memory in Aphasic Subjects

Even though there is a high incidence of verbal primary memory deficit cooccurring with aphasia, few studies incorporating memory paradigms have been performed with aphasic subjects. Research in this area might result in substantial therapeutic economy.

Consistent with the causal relationship hypothesis, a single processing dysfunction might manifest itself in several ways. For example, if a subject is unable to hold more than two items for active processing at any moment, this could result in a number of different performance deficits: The subject may be unable to point to more than one object of a multiple object command; he may be unable to chain sequences of words verbally; or he may be unable to gain meaning from graphically presented sentences but able to gain meaning from single words. Rather than attempt to attack multiple task-specific behaviors, a clinician might chose to directly attack a process dysfunction common to all. Brookshire (1974) alluded to this by suggesting that the auditory comprehension deficit seen in aphasic subjects may not only vary quantitatively but also qualitatively. He isolated a number of patterns of auditory processing dysfunction and implicated a specific processing deficit for each.

Also, when attempting to remediate a dysfunction of task specific behavior we may be attacking a problem through an indirect route. For example, in the case of a subject who is able to point to only one object in a multiobject command, the deficient underlying mechanism may not be a capacity problem at all, but rather, an inability to maintain the information long enough to get any more than one object processed.

What therapeutic benefits would result if a simple coexistence relationship were true? One may assume that even if a disorder of information processing of verbally coded information in primary memory did not produce the symptoms of aphasia, its presence would impinge upon the effectiveness of the therapeutic process. For example, an aphasic individual whose memory capacity only allowed retention and processing of a single unit of information would not benefit from being bombarded with a great quantity and variety of input. Instead, keeping input minimal would facilitate optimal performance.

Therefore, because of the high incidence of verbal memory dysfunction with brain lesions resulting in aphasia, because of the spareseness of information concerning the verbal memory of aphasic individuals, and because of the therapuetic implications of such information, the present study was undertaken. Although many information processes control the flow of information in memory, of specific interest is the presence of rehearsal, a process which normally mediates retention of verbally coded information. Also of interest in this investigation is the relationship between the quality of the verbal output of aphasic subjects and the effeciency of rehearsal.

Memory and Normal Adults

To understand those memory processes which might be susceptible to brain damage resulting in aphasia, the mechanisms of normal adult information processing need to be reviewed.

A dichotomous theory of memory was first discussed by James in 1890. He divided thoughts into two subtypes: The first dealt with those thoughts which could be considered within the time frame of the immediate present (primary memory) and the second encompassed those thoughts that included past events or ideas which must be recalled or retrieved (secondary memory).

Atkinson and Shiffrin (1968) proposed a dichotomous model of memory which serves as the theoretical framework for the present study. The essence of this model is that there are two separate memory systems which have different laws guiding the operation of each. These two memory systems coincide with the task situations of tests of short-term memory and long-term memory.

Crowder (1976) suggested that a description of this model should include two headings: the "structure of memory" and the "control processes." The "structure of memory" includes constraints placed upon the system which determine the structure of the three components (memory stores), routes of transfer between them, and constraints upon information loss from them. In contrast, the "control processes" are voluntarily controlled by the subject and determine the flow of information within and between the structural components. The term "information processing" is used to depict both the structural constraints and the control processes while the term "memory" is used to depict only the structural constraints.

The structural components of the memory system include three memory stores (see Fig. 1). The first stores encountered in the structure are the sensory registers:

> Since the auditory input is always extended over time, some kind of transient memory must preserve it long enough for the process of speech perception to operate. (Neisser, 1967, p. 199)

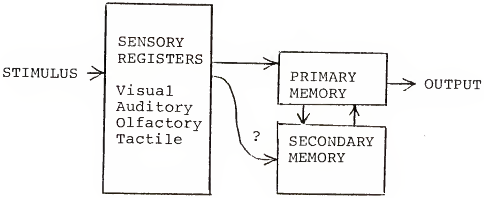


Fig. 1

The Structural Components of Memory and Routes of Information Transfer Between Them

These are modality specific stores which contain all the information being presented to the corresponding sense organ. The duration of this storage is very brief and dependent upon the specific input modality.

Once a message has been collected within the sensory register, it is then transferred to primary memory via secondary memory. This contact with secondary memory is postulated to be a simple recognition process or retrieval of the name of the particular symbol only. Further information is obtained at a later time.

The stimulus is maintained in primary memory for a limited duration (several seconds) and the capacity of this system is limited to the amount of available space at any point in time depending upon the amount of the storage needs of other operations already activated. The secondary memory component consists of a system of unlimited duration and capacity where information may be stored or retrieved when needed.

Primary memory is viewed as the active portion of the memory system. It is in this component that decisions are made as to the fate of the stimulus item. The innate constraints of the structure as well as the voluntary control processes take part in controlling the outcome of these decisions, which may include any one or more of the following:

1. Holding the information for a limited period of time and then forgetting it (for example, repeating a telephone number long enough to complete dialing);

2. Retrieving further information from secondary memory and processing it in conjunction with the new information;

3. Transferring the information into secondary memory for permanent storage;

4. Producing a particular behavioral response associated with that stimulus item.

In recent literature there is a controversy concerning the validity of a dichotomous view of memory. Wickelgran (Crowder, 1976) as well as Craik and Lockhart (1972) feel that the past research suggesting the distinction between primary and secondary memory can be accounted for by a single trace theory. The premise of this theory is that there is only a single memory system and that task situations proposed to represent primary and secondary memory are simply different points along a task continuum. Although the limited data obtained thus far using pathologic populations is suggestive of a dichotomous memory system, the controversy remains.

Memory and Aphasia

A review of research employing memory paradigms with aphasic subjects illustrates the status of knowledge concerning the verbal memory dysfunction associated with aphasia. This review also demonstrates that experimental paradigms established with normal populations can, with minor adjustments, be successfully employed with pathologic populations.

Memory Search Strategies

Swinney and Taylor (1971) used a paradigm, first devised by Sternberg (1966), to investigate the strategies for searching primary memory employed by individuals with aphasia. The subjects were shown a list of digits ranging from two to six items in length. This list was removed from sight and followed by the presentation of a single digit. The subject was required to judge whether the single digit was or was not a member of the list. The dependent variable was reaction time although Swinney and Taylor found that aphasic subjects produced significantly more errors than normals. Sternberg found that the mean reaction time of normal subjects on this task was linearly related to the total number of items in the list rather than to the position of items in the list. Therefore it was suggested that normal subjects examine all items in the list before responding, a serial exhaustive search. This was in contrast to a serial self-terminating search whereby an individual would discontinue the search when a match was found.

The results of the study led Swinney and Taylor to conclude that aphasic individuals show qualitative and quantitative differences in searching primary memory as compared to normal subjects; aphasic subjects performed self-terminating searches while normal subjects searched exhaustively. This conclusion was disputed by Warren (1975) who found that both normal and aphasic subjects employed a serial and exhaustive scan of the stored subset. Warren (1975) presented lists consistent in length with the limited span of aphasic subjects and suggested that because Swinney and Taylor (1971) offered no information on the visual retention spans of their subjects, qualitative group differences might have confounded their results. These conflicting conclusions of differences between aphasic and non-aphasic subjects in strategies for the search of primary memory have not been resolved.

Forgetting from Primary Memory

To assess memory deficits in brain-damaged subjects, Samuels, Butters, and Fedio (1972) and Butters, Samuels, Goodglass, and Brody (1970) employed the Brown-Peterson paradigm. In this paradigm the subject is presented a set of stimuli to retain. A response delay of increments up to 18 seconds is imposed during which time a distractor task (such as performing mental arithmetic) may or may not be presented. This is followed by the subject's reproduction of the stimuli. A measurement is also made of the amount of information the subject can recall immediately after presentation and this is thought to measure initial encoding. Brown (1958) and Peterson and Peterson (1959) found that information was lost at a rapid rate when the distractor task was employed and that the forgetting was relatively complete by the end of the 18 second interval. Three major theories have been presented to account for this rapid forgetting from active memory in normals: decay theory, displacement theory, and interference theory.

The decay theory proposes that the distractor task prevents the subject from attending to the stimulus item which will fade from memory as time passes. Rehearsal is suggested as a process for delaying the fade of the memory trace. The subject recycles the stimulus items over and over and thereby maintains them in active memory. The content of the distractor task is of little import to the followers of this theory. They suggest that its function is merely to block the subject from rehearsing the stimuli.

A number of authors have found, however, that variation in distractor task difficulty results in a comparable difference in the amount of forgetting occurring upon recall. Posner and Rossman (1965) employed a recall task where the subject was asked to retain and reproduce a string of eight digits. An interpolated event included numerical manipulations of varying degrees of difficulty, as measured by the amount of information reduction (Posner, 1964). These included reversed report of two digits, addition of two digits, and "two bit" classification of two digits. A positive correlation was obtained between degree of information lost and degree of task difficulty.

Crowder (1967) looked at the effect of a non-verbal interpolated task upon forgetting from verbal memory. The distractor task involved key pressing while the retention task involved verbal memory (retention of five English words). Levels of difficulty of the key pressing task were established by altering the relationships of a light display to the corresponding key. The easier items involved a one-to-one relationship of light and key as well as a left-to-right orientation. Results suggested, again, that as task difficulty increased, forgetting also increased.

A theory to explain the rapid forgetting from active memory in normal subjects should, therefore, include an explanation of the differential effects of the distractor task content. The displacement theory is one such theory. Followers of this line of thinking suggest that the capacity of the memory store in conjunction with the storage needs of the items will determine the amount of the forgetting which will occur. If the system has N slots and the stimulus items have N-2 slot storage requirements, then the distractor task can employ only two storage slots before information begins to be lost. The differential effects of various distractor tasks result from the different storage needs of each.

The displacement theory, however, does not account for the effect upon performance of the similarity of content between the stimulus items and the distractor items. For example, if the distractor task is mental arithmetic, significantly more information is lost if the items to be remembered are numbers rather than letters. The interference theories attempt to account for this. It may be that the similarity effect is accounted for by the influence of secondary memory.

It is evident that forgetting when distracted cannot be accounted for by a strict decay theory. The differential effect of interpolated tasks is too well established. The choice between the structural approach of the displacement theories and the content approach of the interference theories has yet to be decided. Although suggestive of a simplistic approach, for the purpose of convenience, the control process employed by normal subjects to maintain information in primary memory for brief periods of time shall be referred to in the present study as rehearsal.

Memory Encoding

In both the Butters et al. (1970) and the Samuels et al. (1972) studies, subjects were presented a consonant trigram for retention. The subjects were required to recall the trigram immediately or after a 3, 9, or 18 second delay. When delayed, subjects were asked to count backward by threes from 100 until it was time for recall. The subjects then recalled the items by pointing to them on a card placed before them containing a number of consonants. No measurement of retention without distraction was made.

Butters et al. (1970) found that the left brain-damaged subjects initially encoded significantly less information than did the normal subjects, and that the normal subjects did not differ significantly from right brain-damaged subjects on initial encoding. While comparing, for all subject groups, the slopes of the lines representing retention over 18 seconds when distracted, Butters et al. (1970) found that the group of patients with left parietal lobe lesions had a significantly greater gradient than the other subject groups, which did not differ significantly from one another. Samuels et al. (1972) also found that subjects with right temporal or left temporal lobe lesions had steeper gradients to the slope of their retention lines than non-brain-damaged controls.

Because little was noted concerning the language dysfunction of subjects in these studies, conclusions concerning the effect of aphasia upon retention of information when distracted were not possible. Further considerations for interpretation of these data are discussed later in this chapter.

Proactive Interference

Proactive interference is the experimental phenomenon involving the negative effect of previously presented stimuli upon subsequent performance. Flowers (1973a, 1975) was interested in the degree of and release from proactive interference in aphasic populations.

> If an aphasic patient demonstrates a prominent susceptibility to the operation of proactive interference factors, those factors should be considered when attempting to elicit responses from the patient and when advising speakers as to the optimal manner of communicating with him or her. (Flowers, 1973a, p. 8)

Flowers used an experimental paradigm developed by Wickens (1970) who investigated this phenomenon in normal individuals. In this paradigm subjects are presented (either visually or auditorily) a trigram of items for recall. Intervening between the stimulus presentation and item recall is a time interval during which a distractor task is performed by the subject. Before the next trial begins with the presentation of a new trigram, there is a silence interval. After several trials of the experiment employing items contained in a single category (e.g., consonants) the content of the trigram items is suddenly changed (e.g., numbers).

When accuracy on the initial trial is used as a baseline measure, a significant response decrement over succeeding trials is noted. This response decrement continues until a sudden change in stimulus item content is instituted, at which time response accuracy shifts to approximate baseline scores. The response decrement is labeled proactive interference by Wickens (1970) and the return to baseline accuracy scores upon a change of stimulus content is a release from this phenomenon of proactive interference.

Flowers (1973a, 1975) compared groups of aphasic subjects, brain-damaged non-aphasic subjects, and normal subjects on this task. Both brain-damaged groups included a mixture of etiologies while the brain-damaged non-aphasic group included subjects with left, right, or bilateral hemisphere lesions. The aphasia severity was limited to the 51st to 90th overall percentile on the Porch Index of Communicative Ability (Porch, 1967).

Following a training task, the Wickens method was used to present 18 trigrams containing items exclusively from one of two categories: consonants or animal names. Twelve trials of consonant trigrams were presented followed by six trials of animal names. The subjects were asked to count in a predetermined fashion from a two digit number after each trigram presentation. They were then required to report their responses verbally. Scoring included allowances for both number of items retained as well as the sequence of items retained.

Results indicated that the aphasic group retained fewer items than non-aphasic brain-damaged subjects who, in turn, retained fewer items than the normal group. Proactive interference, however, affected all groups relatively equally. Release from this phenomenon as seen in their sensitivity to stimulus content changes was noted in each. Flowers (1975) concluded therefore that "the reasons for the short-term retention deficits in aphasic persons are unknown at this time" (p. 59). He continued by saying that one possible explanation

> . . . for the discrepancies in recall between the three groups is that the recall problems of the aphasic group may have been due to a more rapid decay of memory traces than was true for the other two groups. That is, a large part of the forgetting of the aphasic subjects may not have resulted from interference of any type. Thus, some short-term forgetting may be expected to occur in brain-damaged subjects under the most optimal circumstances, and the forgetting may be expected to be somewhat more severe in the braindamaged subjects who are aphasic. There is little conclusive evidence from the present study to support or refute the conclusion but of the possible explanations, it seems most likely.
> (Flowers, 1975, p. 49)

In summary, Flowers (1973a, 1975) found that although aphasic subjects performed poorer than control subjects on a task requiring retention of verbal information, they were not significantly affected by proactive interference.

Memory Span

The capacity of primary memory in aphasic individuals has been of interest to a number of investigators as is evident in the number of studies using the classic span task procedure (Miller, 1956). Miller found that humans were able to accommodate a maximum of seven plus or minus two units of information in primary memory at any one time.

DeRenzi and Nichelli (1975) presented four memory span tasks to groups of aphasic subjects, left brain-damaged non-aphasic subjects, and non-brain-damaged subjects. Three of the tasks employed an auditory presentation of the stimulus (digits or pictures) with a verbal or pointing response. The fourth was a spatial memory span task using a visual presentation and a pointing response. DeRenzi and Nichelli found that the aphasics were significantly poorer than control groups on digit forward span, digit pointing span, and picture pointing span. They concluded that an ordered memory task, regardless of modality of input or output, resulted in depressed scores for aphasic subjects.

These findings of a reduced memory span in aphasic subjects, regardless of modality, were also found by Goodglass, Gleason, and Hyde (1970), Flowers (1973b), Albert (1972), Heilman, Scholes, and Watson (1976), and Kim (1976). These findings were not inconsistent with the findings of Milner (1962) who suggested that the left cerebral hemisphere processed verbal information while the right cerebral hemisphere processed visuo-spatial information. The "verbal loop hypothesis" proposed by Glanzer and Clark (1962, 1964) and discussed by Brewer (1969) implies that humans tend to spontaneously encode complex visual information verbally. Therefore, memory tasks using what may appear to be non-verbal stimuli (meaningless figures, geometric shapes) might possibly be mediated by an even more complex verbal strategy than simple pictures. They are, therefore, susceptible to disruption in the ability to encode verbally.

Chunking

Miller (1956) suggests that normals employ a strategy called chunking to maintain greater amounts of information. Since the individual is limited to seven plus or minus two units of information, some items may be grouped into a single unit, thereby reducing the number of units. For example, the sequence of 12 digits, 1-4-9-2-1-7-7-6-1-8-1-2, can be reduced to 3 units, 1492-1776-1812, famous dates in American history. Therefore, a supraspan sequence (one longer than the capacity of the individual) can be maintained in subspan form (one equal to or less than the capacity of the individual) by a chunking strategy.

Flowers (1973b) presented a span task to aphasic subjects and non-brain-damaged subjects in which he used unrelated nouns (man, book) or related nouns (man, woman). He found that both subject groups were assisted by the semantic relatedness of the nouns but aphasic subjects became less assisted as word string length increased to six- or eight-item strings. Since secondary memory is thought to be coded semantically (Anisfeld & Knapp, 1968; Baddeley, 1966; Grossman & Eagle, 1970), the finding that aphasic subjects were less assisted by the semantic relatedness of words than normal subjects might suggest that aphasic subjects have difficulty with secondary memory. Flowers proposed, however, that because aphasic subjects were generally assisted by word associations, because aphasic subjects showed only decreasing assistance of word associations during longer word lists, and because they produced significantly more errors on the total test than non-aphasic subjects, reduced chunking might actually have reflected a primary memory capacity deficit instead of a secondary memory deficit.

Sequencing

The inability to sequence information is thought by Tzortzis and Albert (1974) to characterize the memory deficit seen with aphasia. Although questioned by Rees (1973), Tzortzis and Albert feel that the ability to place auditory information in temporal order is necessary for accurate language processing. Saffran, Marin, Schwartz, and Rubman (1977) presented a digit span task (auditory presentation and pointing response) to two subjects with conduction aphasia and five subjects with Broca's aphasia. The type of aphasia was determined by the subject's performance on the Boston Diagnostic Examination for Aphasia (Goodglass & Kaplan, 1972). Saffran et al. (1977) found sequencing errors characteristic of only subjects with Broca's aphasia.

To summarize the above cited research, aphasic subjects process information differently than non-aphasic subjects in a number of ways. The span studies of DeRenzi and Nichelli (1975) suggest that aphasic subjects display reduced memory spans. This reduced span may be the result of encoding less information when presented, which would be consistent with the findings of Butters et al. (1970) and Samuels et al. (1972), or the result of decreased capacity of primary memory. Swinney and Taylor (1971) conclude in their study that aphasic subjects search primary memory in a manner qualitatively different than non-aphasic subjects but Warren (1975) suggests that the limited memory capacity of aphasic subjects may have contaminated Swinney and Taylor's results. Warren presented lists that were equivalent to the diminished span of the aphasic subjects and found that the qualitative differences in search strategies disappeared.

Flowers (1973a, 1975) looked at the degree of proactive interference in the information processing of aphasic subjects. Although he found that aphasic subjects did not suffer from an excessive amount of proactive interference, Flowers (1973a, 1975) proposed that they might have suffered a "rapid decay of memory traces" (1975, p. 49).

Aphasia and Rehearsal

Warrington and Shallice (1969) and Warrington, Logue, and Pratt (1971) studied individuals with conduction aphasia and found that they displayed decreased memory span for verbal information. They proposed that this span deficit was responsible for the repetition deficit characteristic of conduction aphasic subjects. Heilman, Scholes, and Watson (1976) wondered whether this proposed relationship was also evident in other aphasic subjects with repetition deficits (Broca's aphasic subjects). They also found a span deficit in the Broca's aphasic subjects but suggested a different relationship between repetition and memory dysfunction than Warrington and Shallice (1969) and Warrington et al. (1971). Heilman et al. (1976) suggested that because these aphasic subjects had difficulties with repetition, they were unable to rehearse. Therefore, they were unable to retain information for the span task.

Primacy and Recency

When examining responses to span tasks, one usually sees that the first items presented in a list along with the last items presented are more often recalled than the middle items. Increased retention of the initial items, primacy effect, is thought to reflect those items which are being maintained by rehearsal while increased retention of final items, recency effect, is thought to reflect items being maintained in sensory storage (Crowder, 1976). Therefore, a disruption of rehearsal should result in a decreased primacy effect.

Saffran et al. (1977) found that when processing digit strings, subjects with Broca's aphasia displayed recency in their performance while subjects with conduction apahsia did not. Flowers (1976) warned that comparing population groups with different capacities of their memory systems (quantitative differences) may result in what erroneously appears to be qualitative differences in memory processing. Therefore Saffran et al. (1977) compared only those Broca's aphasic subjects (N = 2) who had memory spans equal to the conduction aphasic subjects in the study and the differences between the two groups in recency were still evident. The inference here would be that conduction aphasics suffer a decreased span due to a deficit in the sensory register rather than a deficit in rehearsal. In turn, the Broca's aphasics suffer a decreased span due to a general reduction in performance rather than a difficulty in rehearsal. These findings refute the hypothesis of Heilman et al. (1976) that Broca's aphasics and conduction aphasics have decreased memory spans which result from inefficient rehearsal.

Using an aphasic subject group not delineated by type of aphasia, Locke and Deck (1978) also looked at recency and primacy in performance on a probe recall task. The distinguishing factor of the independent variables in the Locke and Deck study was the nameability of the stimulus items, as determined by a naming proficiency task. For each subject, one half of the stimuli were nameable pictures and the other half were unnameable pictures. The criterion for inclusion in the nameable group was that the pictures were "consistently named correctly within four seconds of continuous exposure" (p. 230). For inclusion in the unnameable group, the criterion was that the pictures were "never named--even with wrong names--within 20 seconds of continuous exposure" (p. 230).

The subjects were presented three pictures, the pictures were turned over, a probe picture was presented, and the subjects were to turn over the matching picture. The investigators found that the aphasics showed recency but no primacy on unnameable items while they did show primacy and recency on nameable items. They propose that the naming difficulty displayed by the aphasic subjects impinged upon effective rehearsal resulting in a loss of information. Therefore, it would appear from the findings of Saffran et al. (1977), Warrington and Shallice (1969) and Warrington et al. (1971), Heilman et al. (1976), and Locke and Deck (1978) that there is a link between verbal output disabilities in aphasic individuals and impaired memory span.

Many information processes are required to receive, maintain, and reproduce a list of items such as those used in a span task. The Locke and Deck (1978) study and the Saffran et al. (1977) study were the only ones which examined performance (the primacy effect) directly attributed to rehearsal. The findings of Locke and Deck suggest that the process of rehearsal in aphasic individuals exists when items are verbally codeable and when a verbal code is unavailable, rehearsal is non-existent. The Locke and Deck study examines only the effect of verbal codeability on rehearsal but does not look at the efficiency of rehearsal itself, however. Research is needed to determine the existence and efficiency of the rehearsal of information once coded into the memory system in aphasic individuals. The Brown-Peterson paradigm is one which allows the separation of initial encoding and rehearsal.

The Brown-Peterson Paradigm and Aphasia

Although the Brown-Peterson paradigm was previously used with left brain-damaged subjects by Samuels, Butters, and Fedio (1972) and Butters, Samuels, Goodglass, and Brody (1970), questions remain concerning rehearsal in aphasic subjects. For example, the Samuels et al. (1972) study compared the performance of right temporal lobectomy patients to the performance of left temporal lobectomy patients. One might assume that a language disturbance could result from a left temporal lobectomy but no reference was made to the presence of language dysfunction in their subject groups. In the Butters et al. (1970) study, 15 of the 16 left brain-damaged subjects displayed language disturbance but behavioral characteristics of these language disturbances were limited, and therefore conclusions concerning rehearsal in these subjects were difficult.

In both the Samuels et al. (1972) study and the Butters et al. (1970) study there was no within group comparison of performance when distracted to performance when not distracted. Instead, between group comparisons of performance when distracted were made which did not rule out the effect of differences in the quantity of information initially encoded. From the research on the memory span (Goodglass, Gleason, & Hyde, 1970), it would appear that aphasic subjects are limited in the quantity of information that they process at any moment. Therefore, group comparisons would yield little information concerning qualitative differences of rehearsal between subject groups. Between group comparisons would be useful, however, in evaluating differences in initial encoding and overall test performance.

Another methodological difficulty of the Butters et al. (1970) study resulted from the relative difficulty of a single distractor task for each subject group. It is probable that normal subjects would perform the backward counting task with greater ease than the aphasic subjects, and this difference may result in differences in the effectiveness of the distractor task.

Statement of the Purpose

The purpose of the present study was to determine whether a sample of persons with aphasia employed rehearsal as a strategy for maintaining verbally coded information in primary memory and whether the fluency of their verbal output correlated with the efficiency of their rehearsal.

The experimental method proposed to examine rehearsal in aphasic subjects was based upon the paradigm first described by Brown (1958) and Peterson and Peterson (1959) in which the subject was presented a set of stimuli to retain and a response delay was imposed during which time a distraction was or was not presented. The subject then reproduced the stimuli. In non-brain-damaged subjects the presence of distraction resulted in poorer performance than compared to performance when not distracted. It was thought that poorer performance during distraction resulted from interference of the distractor task with rehearsal.

In the present study the Brown-Peterson procedure was used to examine rehearsal in aphasic individuals by comparing their performance when distracted to their performance when not distracted. Non-brain-damaged subjects and right brain-damaged subjects were used as control groups. A recognition response paradigm, rather than recall, was used to circumvent the effect of the verbal output difficulties of aphasic subjects upon performance when compared to non-aphasic subjects. The aphasic group was divided into fluent aphasia and non-fluent aphasia groups for the purpose of comparing the performance of aphasic groups displaying qualitatively different verbal output.

Hypotheses

Because of the high incidence of verbal memory disorders in patients suffering cerebral lesions resulting in aphasia (Milner, 1962) and because aphasic subjects have difficulty processing verbal-linguistic information, it was anticipated that aphasic subjects would perform generally poorer than right brain-damaged subjects or non-brain-damaged subjects on any memory task using verbal-linguistic stimuli.

Consistent with the language disturbance of aphasia and also the findings of Butters et al. (1970), aphasic subjects would be expected to encode less information into the memory system than non-aphasic subjects. Also, assuming that differences in output processing correlate with differences in input processing, one would expect a difference in the quantity of information initially encoded by fluent and by non-fluent aphasic subjects.

Based upon the assumption that decreased rate and quantity of verbal output would have a negative effect upon the efficient recycling of information in primary memory, and based upon the findings of Locke and Deck (1978) that verbal output difficulties coexist with inefficient or nonexistent rehearsal, it was predicted that fluent aphasic subjects would rehearse while non-fluent aphasic subjects would not. If a subject rehearsed effectively, information would be maintained indefinitely. In contrast, if a subject rehearsed inefficiently, information would be lost as time progressed. Therefore, if non-fluent aphasic subjects had difficulty with rehearsal, they would lose information as time progressed when not distracted.

The preceding rationale resulted in the establishment of the following hypotheses to be tested. The 0.05 level of confidence was employed in the present study.

1. Aphasic subjects will retain significantly fewer items in all experimental conditions than right brain-damaged subjects or non-brain-damaged subjects.

2. Aphasic subjects will initially encode significantly fewer items than right brain-damaged subjects or non-brain-damaged subjects.

3. Significant differences will exist between the fluent and non-fluent aphasic groups in the quantity of information initially encoded.

4. When undistracted, non-fluent aphasic subjects will show a significant loss of information on comparisons of retention at increasing lengths of the retention interval.

5. When undistracted, non-brain-damaged subjects, right brain-damaged subjects, and fluent aphasic subjects will show no significant loss of information on comparisons of retention at increasing lengths of the retention interval.

6. The right brain-damaged subject group and the non-brain-damaged subject group shall display significantly worse performance on tasks when distracted as compared to performance on tasks when undistracted.

7. Non-fluent aphasic subjects will be more likely than fluent aphasic subjects to display performance when distracted that is not significantly different than performance when undistracted.

8. In aphasic subjects, the severity of aphasia and the severity of the auditory comprehension deficit will correlate significantly with the amount of information lost when distracted.

CHAPTER II
METHODS AND PROCEDURES

Subjects

Experimental Groups

The experimental groups were composed of aphasic subjects who, at the time of testing, were being seen for speech and language treatment by the Audiology and Speech Pathology Service at the Veterans Administration Hospital, Gainesville, Florida. For the present study, aphasia was defined as:

> A language disorder resulting from an infarction of the language dominant cerebral hemisphere. This language disorder crosses, with varying degrees, all input (auditory; visual) and output (verbal; gestural; graphic) modalities and affects, to some extent, all linguistic systems (phonologic; morpho-syntactic; semantic). It is characterized by inefficient processing of linguistic information. It may coexist with but not result from sensory disorders, generalized intellectual impairment, neurogenic motor programming or motor disorders, or auditory or visual perceptual disorders.

All experimental subjects were diagnosed by a physician as having suffered a unilateral infarction within the left cerebral hemisphere and confirmation findings from EEG, brain scan, or EMI scan were obtained in 11 cases. Pertinent neurological data were obtained from the medical histories. Nineteen of the subjects had incurred cerebral infarction as a result of a cerebrovascular event and one received brain-damage due to closed head trauma.

The presence and severity of aphasia were determined by the clinical judgment of two certified (American Speech and Hearing Association Certificate of Clinical Competence in Speech Pathology) speech pathologists in conjunction with standard evaluative measures: the Porch Index of Communicative Ability (Porch, 1967) and a revised version (LaPointe, Anderson, Cutler, Horsfall, McCall, & Ready, 1971) of the Token Test (DeRenzi & Vignolo, 1962).

A bimodal distinction among the aphasic subjects was made by the speech pathologists based upon fluency of verbal output. As suggested by Goodglass and Kaplan (1972), phrase length and verbal agility, "the ease with which the patient articulates phonemic sequences . . . " (p. 25), were the factors used to make this distinction. The verbal output of fluent aphasic subjects was described by Goodglass and Kaplan as:

> . . . marked by facility in articulation and many long runs of words in a variety of grammatical constructions, in conjunction with word-finding difficulty for substantives and picturable action words. (1972, p. 54)

On non-fluent aphasics Goodglass and Kaplan state:

> The flow of speech is more or less impaired at all levels of speech initiation, finding and sequencing of articulatory movements and production of grammatical sequences. (1972, p. 54)

Based upon this verbal fluency distinction, the two experimental groups were the fluent aphasia group and the non-fluent aphasia group. Each group was composed of ten adult males. See Appendix A for individual and group information regarding age, months postonset, years of formal education, confirmation data of lesion site, presence of motor defect, Porch Index of Communicative Ability and Token Test performance, history of ethanol abuse, and etiology.

Control Groups

The first control group, right brain-damaged group, included ten adult male subjects who had suffered unilateral damage to the right cerebral hemisphere as diagnosed by a physician, and they each presented without specific language dysfunction. Support from EEG, brain scan, or EMI scan was obtained in five cases. Cerebrovascular accident was the proposed etiology in all cases. Pertinent neurological information was obtained from the medical history. At the time of testing all subjects were being seen on an inpatient or outpatient basis by the Physical Therapy Department of the Rehabilitative Medicine Service of the Veterans Administration Hospital, Gainesville, Florida. Appendix A contains information about each individual concerning age, years of formal education, months postonset, motor deficit, neglect, history of ethanol abuse, etiology, and confirmational data of lesion site.

The second control group, the normal group, was comprised of ten adult male subjects who had no history of central nervous system damage. At the time of testing, eight subjects were inpatients on the medicine wards of the Veterans Administration Hospital, Gainesville, Florida, and two were outpatients of the Audiology and Speech Pathology Service. Pertinent medical information was obtained from the medical histories. No subject presented a history of renal failure, which might result in changes in mental status due to metabolic encephalopathy (Wintrobe, Thorn, Adams, Braunwald, Isselbacher, & Petersdorf, 1974). Two cases were noted to be abusers of ethanol. Appendix A contains information related to each individual's age, years of formal education, history of ethanol abuse, and the current hospital diagnosis.

Table 1 contains, for each of the four groups, the ranges, means, and standard deviations of age and years of formal education. For the groups with brain damage (non-fluent aphasics, fluent aphasics, and right brain-damaged subjects), ranges, means, and standard deviations of months postonset are included. Information regarding the aphasics as a group (non-fluent aphasics and fluent aphasics) and the brain-damaged subjects as a group are included as well. Hereafter, references to aphasic subjects as a group refer to fluent and non-fluent aphasic subjects combined and references to the group of brain-damaged subjects refer to the right brain-damaged subjects, fluent aphasic subjects, and non-fluent aphasic subjects combined.

Table 1

Group Information

SUBJECT GROUPS		AGE	YEARS OF EDUCATION	MONTHS POST-ONSET
NORMAL SUBJECTS	RANGES	31-75	8-16	NA
	MEANS	55.2	12.2	NA
	STANDARD DEVIATIONS	14.53	2.44	NA
RIGHT BRAIN-DAMAGED SUBJECTS	RANGES	46-72	5-19	1-39
	MEANS	59.8	9.2	6.1
	STANDARD DEVIATIONS	8.11	4.47	12.05
FLUENT APHASIC SUBJECTS	RANGES	37-66	0-17	1-28
	MEANS	57.7	9.3	10.8
	STANDARD DEVIATIONS	8.47	4.69	9.09
NON-FLUENT APHASIC SUBJECTS	RANGES	40-67	8-14	1-35
	MEANS	56.4	11-3	14.9
	STANDARD DEVIATIONS	9.08	2.41	13.24
APHASIC SUBJECTS[a]	RANGES	37-67	0-17	1-35
	MEANS	57.1	10.3	10.6
	STANDARD DEVIATIONS	8.57	3.77	11.18

Table 1 - continued

SUBJECT GROUPS		AGE	YEARS OF EDUCATION	MONTHS POST-ONSET
BRAIN-DAMAGED SUBJECTS[b]	RANGES	37-72	0-19	1-39
	MEANS	58.0	9.9	10.6
	STANDARD DEVIATIONS	8.39	3.97	11.18

APHASIC SUBJECTS[a]: Fluent and non-fluent aphasic subjects combined.

BRAIN-DAMAGED SUBJECTS[b]: Fluent and non-fluent aphasic subjects and right brain-damaged subjects combined.

Method

Subjects were asked to remember a string of three nouns. The experimental conditions of this task included manipulations of the length of response delay and presence or absence of a distraction task during the interval between stimulus presentation and response report. This retention interval varied from immediate report (0 second delay) to 3, 9, or 18 second delays. These delay intervals were specifically chosen to be consistent with the method used by Samuels, Butters, and Fedio (1972) with Butters, Samuels, Goodglass, and Brody (1970) such that comparisons between studies would be possible. A recognition response was obtained by requiring the subjects to identify (point to) the three target stimuli among twelve pictures on a response page. This method allowed the examiner to measure the quantity of information maintained, at least at the recognition level, over increasing amounts of time when undistracted and also when distracted.

Materials

Target Stimulus Construction

Twenty-six nouns were selected for the stimulus set from the Jones and Wepman (1966) list of frequently spoken words. See Appendix B for the words selected for the present investigation and information concerning the number of subjects who used the word in the Jones and Wepman study, the mean number of occurrences per 10,000 consecutive words, and the standard deviation of the relative frequency of occurrence.

The target stimuli were constructed by randomly assigning each of the 26 nouns in the stimulus set to 28 strings of three (see Appendix C). Each string was presented auditorily to the subject via tape recording.

Response Material Construction

The response materials (see Appendix D for an example) consisted of 28 pages of 12 simple black and white line drawings traced from the response booklet of the *Peabody Picture Vocabulary Test* (Dunn, 1959) or drawn by the examiner. Three drawings on each page represented the three nouns of the corresponding string of target stimuli. The 26 nouns of the stimulus set were then randomly assigned as the nine non-target pictures on the response pages. This was accomplished such that each noun never appeared, either as a target stimulus picture or as a non-target picture, more than once per page. Each noun appeared on three occasions as non-target pictures. The subject was instructed to identify the three target stimuli of the particular trial by pointing to them on the response page.

Distractor Tasks

Six distractor tasks varying in content were employed. These included counting backward by threes, twos, or ones or counting forward by threes, twos, or ones. The particular distractor task used by each subject was determined by the counting proficiency task described in the Procedures section of the study. The content of the distractor task remained constant for each individual throughout the test.

Experimental Conditions

The seven conditions resulting from manipulation of response delay and presence or absence of distraction are summarized in Table 2. There were four trials in each condition, resulting in a total of 28 trials. Two orders of presentation (A and B) were constructed and are summarized in Appendix E. Presence or absence of the distractor task was varied such that distraction was present on 12 of the first 14 trials in Order A and not present in the final 14 trials of the test. Conversely, for Order B, the distractor task was present on the last 14 trials and not present on the first 14 trials of the test. The length of the retention interval was randomly distributed within the trials where the distractor task was present and also randomly distributed among the non-distractor trials. Two trials of zero delay or immediate report occurred in the first half of the test and two trials in the second half. Presentation order was counterbalanced within subject groups such that five subjects from each group received Order A and the remaining five subjects received Order B.

Table 2

Experimental Conditions Existing During Interval Between Target Stimulus Presentation and Response Report

CONDITION	LENGTH OF RETENTION INTERVAL[c]	PRESENCE OR ABSENCE OF DISTRACTOR TASK[b]
1	18 SECONDS	+
2	9 SECONDS	+
3	3 SECONDS	+
4	0 SECONDS	a
5	3 SECONDS	−
6	9 SECONDS	−
7	18 SECONDS	−

[a]: Immediate report precludes initiation of distractor task.

DISTRACTOR TASK[b]: + = distractor task employed;
− = no distractor task employed.

RETENTION INTERVAL[c]: Retention interval = interval between presentation of target stimuli and response report.

Tape Recording Construction

The tape recordings were made on a Sony Stereo Solid State Tape Recorder, TC 270, using a Sony Electret Condenser Microphone, ECM-250. The speaker was an adult male who spoke standard American dialect. Each string of target stimuli was recorded at an approximate rate of one noun per second. This master recording was used to construct two experimental tapes reflecting presentation Orders A and B. A tone was inserted in the tapes on appropriate trials following each target stimulus string presentation to alert the examiner of the presence of the distraction task condition. Nondistraction conditions were indicated by a lack of the tone following the target stimulus presentations. The end of the retention interval was indicated by an audible click inserted on the tape after the appropriate time delay. Approximately five seconds of silence following the click separated trials.

Procedures

Each subject was tested individually while seated at a table beside the examiner. The format of task presentation was as follows:

1. Counting proficiency task
2. Training task
3. Experimental task

4. Independent measures (fluent aphasic and non-fluent aphasic subject groups only)
    a. Porch Index of Communicative Ability
    b. Token Test

Counting Proficiency Task

The content of the distractor task for each individual was determined by a method described by Flowers (1975). The subject was asked to count backwards by ones from various two-digit numbers presented on 3 x 5 index cards. If successful, he was asked to count by twos, then by threes. If he was unsuccessful, he was asked to count forward from a two-digit number by ones, twos, or threes. This procedure continued until the subject was unable to say 3 two-digit numbers within 15 seconds on 6 trials or if he was able to count backwards by threes. Appendix F contains information regarding the counting proficiency established by subjects in each subject group.

The numbers on the index cards were selected such that 6 in every sequence of 10 between 20 and 29 occurred. For example, 6 numbers between 20-29 were used, 6 numbers between 30-39, etc. These were written in one inch block numerals with a black marking pen and presentation order was randomized across subjects. See Appendix G for a list of the numbers used.

Training Task Procedure

Once the counting proficiency had been established, the training task commenced. Four stimulus presentations occurred during this period, and the format and dialogue was standard for all subjects.

Stimulus Presentation #1

Format:

Live Voice Stimulus Presentation	Immediate Report

Dialogue:

There are 12 pictures on this page. They are _____ (named all 12 pictures while pointing to each). I shall name three of them and your job is to point to the pictures I named. I can only say them once so if you have forgotten them, be sure to guess. Remember, don't tell me the names, just point to the pictures.

Stimulus Presentation #2

Format:

Live Voice Stimulus Presentation	Six Second Delay	Report

Dialogue:

We will do this one just like the one before except that I will make you wait for a short time before I will show you the pictures. Remember, if you forget, be sure to guess.

Stimulus Presentation #3

Format:

Live Voice Stimulus	Six Second Delay + Counting Task	Report

Dialogue:

We will do the next one just like the one before except that when you hear this beep, you will start counting by _____ (dependent upon counting proficiency) from the number on this card. Then stop counting when I show you the pictures and point to the ones I named. Let us try it.

Stimulus Presentation #4

Format:

Recorded Stimulus	Six Second Delay + Counting Task	Report

Dialogue:

Let us try that again except now listen to it on the tape recording.

Experimental Task Procedures

Immediately after completion of the training task, the presentation of the experimental task began. The following instructions were employed.

> I want you to do the rest of these pages just like the last one. Sometimes I will have you count and other times I will not. I will let you know when to count. Do you have any questions before we go on? Do the best you can and be sure to guess if you cannot remember. Let us begin.

The recording of the stimulus items was initiated, and response pages were hidden from view until the audible click on the tape signaled that the retention interval was completed. The examiner then placed the page on the table in front of the subject and pressed the pause button on the tape recorder while the subject responded by pointing to 3 of the 12 pictures. If the subject pointed to fewer than three, he was encouraged to continue. If he pointed to more than three, he was reminded that only three were required and was asked to reproduce his answer accordingly. The examiner recorded the subject's responses on the score sheet (see Appendix H).

The presence of the distractor condition was indicated on the tape by a tone. If the tone was present, the examiner placed a 3 x 5 index card containing a two-digit number on the table in front of the subject and said: "Count by _____ (as determined by performance on the counting proficiency task) from the number _____." The subject continued to count until the response page was presented, signaling the end of the retention interval.

The absence of the distraction condition was indicated on the tape by an absence of any tone following the stimulus presentations. The examiner and subject sat in silence until the audible click signaling the end of the retention interval sounded and the response page was then presented.

Dependent Measures

The corpus of data from each subject was analyzed for the following information.

1. Total item retention was the total number of correct responses during the entire test (84 possible). This analysis was considered a general index of information processing on the experimental task.

2. Initial encoding was the total number of correct responses at immediate report (12 possible). This analysis was considered an index of the quantity of information that the subject entered into the memory system before the effects of distraction or response delay.

3. Rate of information loss was a comparison of the slope of the line representing recognition at 3, 9, and 18 seconds when distracted with the slope of the line when undistracted for each subject group. Rate of information loss was also analyzed by comparing the accuracy of performance at each time interval when distracted with performance at each time interval when undistracted. These analyses were thought to reflect the effect of distraction upon performance accuracy.

4. Effect of time upon performance involved comparisons of the accuracy of performance after each succeeding increase (3, 9, or 18 seconds) in the retention interval when undistracted. This analysis was considered to reflect the effect of increases in the duration of response delay upon performance.

5. Counting productivity was the total quantity of numbers produced during the experimental task. This analysis was considered a method for comparison across subjects of distractor task difficulty.

6. The effect of neglect was evaluated by comparing the number of responses the subject produced on the right versus left side of the response page. This analysis was included in the present study to rule out the effects, upon subject performance on the experimental task, of neglect, a symptom often associated with right parietal lobe disease. Neglect is operationally defined as the propensity to respond on one side of the response page significantly ($p < 0.05$) more often than the other.

7. The number of errors occurring on stimulus items presented in the initial, medial, or final position of the target stimulus sequence were calculated for each subject. This analysis was performed to evaluate differences between groups on position of error items.

8. The effect of test length upon performance was evaluated by comparing the performance on the first half of the experimental task with the performance on the second

half for each subject group. This analysis was performed to rule out the effects of fatigue upon performance of the experimental task.

Independent Measures

The Porch Index of Communicative Ability (Porch, 1967) was administered to all aphasic subjects (fluent aphasic subjects and non-fluent aphasic subjects). This battery consists of 18 subtests assessing a variety of language functions employing input (visual, auditory) and output (verbal, gestural, graphic) modalities. There are 10 items per subtest resulting in a total of 180 responses and each response is scored using a 16-point multidimensional scoring system. Five dimensions of patient response are incorporated into this scoring system and include accuracy, responsiveness, promptness, completeness, and efficiency. The attributes which make this test desirable for use in this study were standardized administration procedure, a multidimensional scoring system, and a wide range of measured language behaviors. These attributes allowed quantitative comparisons of language functioning between the aphasic groups.

An overall mean score for each subject was obtained by averaging the 18 subtest means. Appendix I includes overall mean scores for each subject. Table 3 includes group means, ranges, and standard deviations.

Table 3

Group Overall Mean Scores
Porch Index of Communicative Ability
Aphasic Subjects

	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS	APHASIC SUBJECTS[a]
MEANS	11.3	10.0	10.6
STANDARD DEVIATIONS	1.69	1.42	1.67
RANGES	8.3-14.0	6.9-11.7	6.9-14.0

APHASIC SUBJECTS[a]: Fluent and non-fluent aphasic subjects combined.

A modification (LaPointe et al., 1971) of the Token Test (DeRenzi & Vignolo, 1962) was administered to all aphasic subjects. The five-part examination consists of commands requiring the manipulation of objects. Commands in each part vary in message length and linguistic complexity with minimal linguistic redundancy. Message length varies from two critical elements to six critical elements. Variations in linguistic complexity are accomplished by the addition of preposition, conjunction, or subordinate clauses in Part V to the standard verb-object construction used in the first four parts. Reductions in linguistic redundancy are accomplished by selecting test items which lack clues given by the situation, the nature of the objects, or the verbal context. Therefore, the subject must process each word to accurately understand a command. The objects (tokens) vary in the dimensions of color (white, red, green, yellow, blue), shape (rectangles, circles), and size (small, large). Plus-minus scoring was employed. Appendix I includes the number of correct items of a possible 40 for each subject and Table 4 includes group means, ranges, and standard deviations.

Table 4

Group *Token Test* Performance
Aphasic Subjects

	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS	APHASIC SUBJECTS[a]
MEANS[b]	15.5	8.1	11.8
STANDARD DEVIATIONS	6.47	6.69	7.45
RANGES	7-25	0-20	0-25

APHASIC SUBJECTS[a]: Fluent and non-fluent aphasic subjects combined.

MEANS[b]: Total possible = 40.

CHAPTER III
RESULTS

Group Comparisons

Total Item Retention

Total item retention scores for each individual subject were obtained by summing all correct responses of the 84 possible in the test, regardless of experimental condition. See Appendix J for total item retention scores for each individual. Table 5 contains means, standard deviations, and ranges for the four subject groups.

Subject groups were compared on total item retention by use of a one-way analysis of variance. The F-test was significant ($F = 19.23$, $df = 3,36$, $p < 0.0001$) indicating a difference between the four groups. A Duncan's multiple range procedure (Steel and Torrie, 1960) was then employed to determine which scores were significantly different at the 0.05 level of significance. Performance of the normal subjects was not significantly different on total item retention from that of the group of right brain-damaged subjects but all other comparisons of the four groups were significant.

The effect of aphasia upon total item retention was investigated by comparing the performance of the right

Table 5

Total Item Retention

	SUBJECT GROUPS			
	NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
MEANS[a]	73.9	66.8	53.6	38.9
STANDARD DEVIATIONS	4.82	9.19	13.15	14.57
RANGES	67-80	51-77	29-73	18-64

MEANS[a]: Total possible = 84.

brain-damaged subjects with the performance of the aphasic subjects (non-fluent aphasic and fluent aphasic subjects combined). A two-sample t-test indicated that the right brain-damaged subjects retained significantly more items than aphasic subjects ($t = 4.78$, $df = 28$, $p < 0.01$).

In summary, statistical analysis of total item retention scores among subject groups indicated that subjects with aphasia process significantly less information than do non-brain-damaged (normal) subjects or right brain-damaged subjects. Normal subjects and right brain-damaged subjects were not significantly different from each other on total item retention. But this analysis does not reveal the component or components resulting in the significant difference in total item retention scores. Therefore, analyses of initial encoding, effects of distraction, and effects of increasing length of response delay were examined in subject groups.

Initial Encoding

The amount of information initially encoded was measured by requiring the subjects to respond immediately (zero second delay) after the stimulus presentation. Appendix J contains initial encoding scores for each individual, and Table 6 contains means, standard deviations, and ranges for the four subject groups. Group means indicate that normal subjects encoded more items initially than right brain-damaged subjects, fluent aphasic subjects, and non-fluent aphasic subjects respectively.

Table 6

Initial Encoding Scores

	SUBJECT GROUPS			
	NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
MEANS [a]	11.7	11.2	9.1	6.2
STANDARD DEVIATIONS	0.48	0.63	2.85	2.66
RANGES	11-12	10-12	3-12	2-11

MEANS[a]: Total possible = 12

A one-way analysis of variance indicated significant ($F = 16.64$, $df = 3,36$, $p < 0.01$) differences between the subject groups in the amount of information initially encoded. Two-sample t-tests were then performed to compare specific group differences. Subjects without brain damage (normal subjects) were found to encode significantly more information than right brain-damaged subjects ($t = 1.99$, $df = 18$, $p < 0.05$), right brain-damaged subjects significantly more than fluent aphasic subjects ($t = 2.28$, $df = 18$, $p < 0.05$), and fluent aphasic subjects significantly more than non-fluent aphasic subjects ($t = 2.39$, $df = 18$, $p < 0.05$).

The effect of brain damage on initial encoding was evaluated by comparing subjects without brain damage with the group of brain-damaged subjects. Normal subjects encoded significantly more information than brain-damaged subjects ($t = 4.036$, $df = 38$, $p < 0.005$).

The effect of aphasia on initial encoding was evaluated by comparing non-aphasic brain-damaged subjects (right brain-damaged subjects) with aphasic subjects. Aphasic subjects encoded significantly less information than non-aphasic subjects ($t = 6.18$, $df = 28$, $p < 0.005$).

In summary, the statistical analysis of initial encoding scores indicated that brain-damaged subjects encoded fewer of the nouns to begin with than subjects without brain-damage. This accounted for a portion of their deficit in total item retention scores. Non-fluent aphasic subjects encoded the least amount of information, followed by fluent aphasic subjects and right brain-damaged subjects.

Rate of Information Loss Over Time When Distracted and When Not Distracted

Four trials of each experimental condition resulted in 12 responses per condition per subject. Correct responses during each condition were summed yielding an accuracy score for that condition (see Appendix K). Figures 2, 3, 4, and 5 show the mean performance of each of the 4 groups during the distraction condition and during the non-distraction condition over the 18 second retention interval. The slopes of the lines represent the rate of information loss during the period from 3 to 18 seconds. The immediate report condition (zero second delay or initial encoding score) was not included in this analysis.

A linear regression model was used to compare the slope of the line representing each group's performance during the distraction condition with the slope of the line representing their performance during the non-distraction condition. The differences in the slopes of the distraction and non-distraction lines were not significant for any subject groups except the fluent aphasic subjects. The slope of the line reflecting the rate of information loss during the distraction condition in fluent aphasic subjects was significantly ($p < 0.005$) greater than the slope of the line reflecting rate of information loss during the non-distraction condition. Therefore, it would appear that only the fluent aphasic subjects suffered a loss of information when distracted.

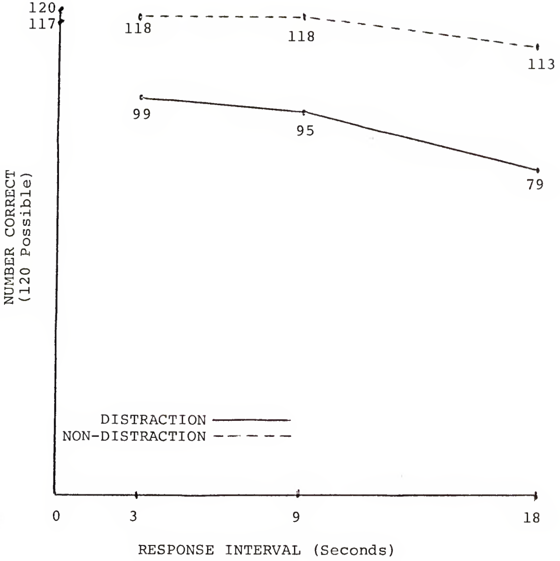


Fig. 2

Retention Performance of Normal Subjects

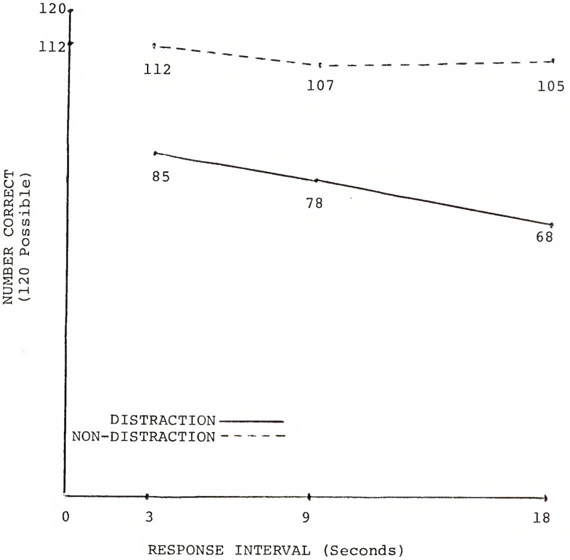


Fig. 3

Retention Performance of Right Brain-Damaged Subjects

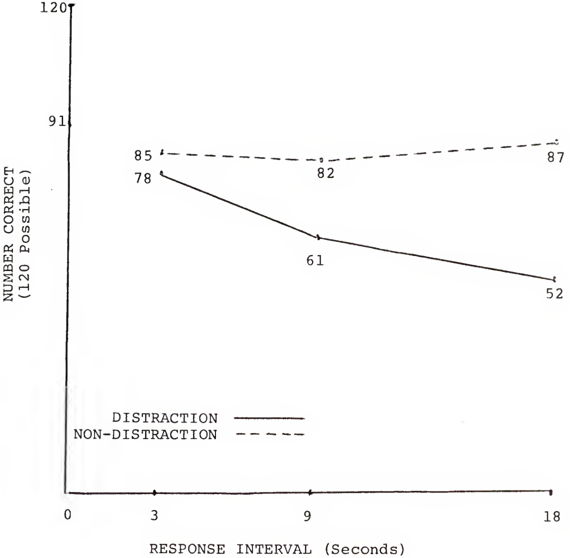


Fig. 4

Retention Performance of Fluent Aphasic Subjects

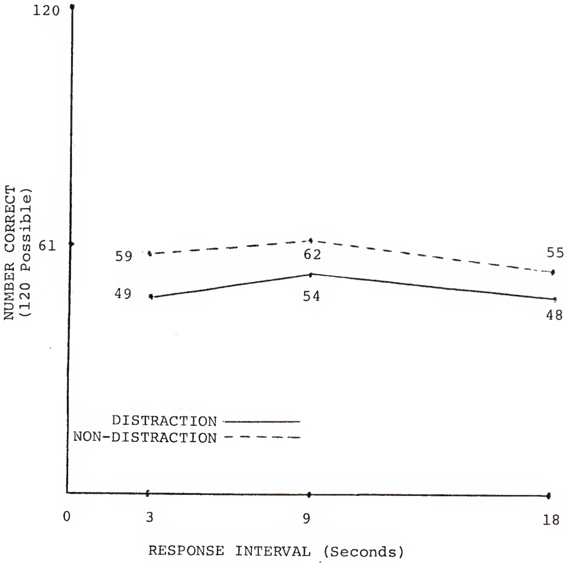


Fig. 5

Retention Performance of Non-Fluent Aphasic Subjects

When examining Figs. 2 and 3, however, it is apparent that although the slopes of the lines are not significantly different, as tested by the linear regression model, the amount of information retained at any point in time is different in the distraction versus non-distraction condition. Therefore, for subjects in each group, mean accuracy scores for distraction conditions were compared with their mean accuracy scores at 3 seconds, as well as 9 seconds and 18 seconds for non-distraction conditions.

Using a two-sample t-test, the accuracy scores during the distractor condition were significantly lower than the accuracy scores during the non-distraction condition at 3 seconds ($t = 3.98$, $df = 18$, $p < 0.005$), at 9 seconds ($t = 3.977$, $df = 18$, $p < 0.005$), and also at 18 seconds ($t = 4.43$, $df = 18$, $p < 0.005$) for the normal subject group. The right brain-damaged subject group also showed significantly lower accuracy scores when distracted than when not distracted at 3 seconds ($t = 3.199$, $df = 18$, $p < 0.005$), at 9 seconds ($t = 3.45$, $df = 18$, $p < 0.005$), and 18 seconds ($t = 5.06$, $df = 18$, $p < 0.005$). For the non-fluent aphasic group, no significant differences were noted when comparing the accuracy scores during the distractor condition with the accuracy scores during the non-distractor condtion at 3 seconds ($t = 0.73$, $df = 18$, NS), at 9 seconds ($t = 0.687$, $df = 18$, NS), or at 18 seconds ($t = 0.829$, $df = 18$, NS). For the fluent aphasic group, the accuracy scores during the distraction condition were significantly lower than scores obtained during the non-distraction condition at 18 seconds ($t = 3.142$, $df = 18$, $p < 0.005$). A significant difference was also noted at nine seconds ($t = 2.12$, $df = 18$, $p < 0.025$). At three seconds, no significant differences were noted between accuracy socres from the distractor condition and accuracy scores from the non-distraction condition ($t = 0.716$, $df = 18$, NS). This analysis included only comparisons of information loss after three seconds, however, and no comparisons of information loss between stimulus presentation and response report at three seconds.

An estimate of the amount of information lost in the first three seconds is obtained by comparing accuracy scores at three seconds for distractor condition or accuracy scores at three seconds for non-distractor condition with the initial encoding (immediate report) accuracy score. A two-sample t-test was used. Significant differences were noted between the initial encoding scores and three second delay scores during the distraction condition in both the normal group ($t = 3.73$, $df = 18$, $p < 0.005$) and the right brain-damaged group ($t = 3.62$, $df = 18$, $p < 0.005$). Comparisons in the fluent aphasic group ($t = 1.22$, $df = 18$, NS) and non-fluent aphasic group ($t = 1.08$, $df = 18$, NS) were not significant. Differences between initial encoding scores and three second delay scores during the non-distraction condition were evaluated in the normal group ($t = 0.49$, $df = 18$, NS), right brain-damaged group ($t = 0.50$, $df = 18$, NS), and non-fluent aphasic group ($t = 0.136$, $df = 18$, NS) and none of these comparisons were significantly different.

In summary, subjects without brain damage, right brain-damaged subjects, and fluent aphasic subjects suffered a rapid loss of information when distracted while non-fluent aphasic subjects did not. Subjects without brain damage and right brain-damaged subjects suffered this rapid loss during the first three seconds and on, while fluent aphasic subjects suffered this rapid loss only after the first three seconds.

The Effects of Time

The effect of delaying responses was measured by comparing the accuracy scores at 3 seconds with the accuracy scores at 9 seconds and at 18 seconds during the non-distraction condition. A one-way analysis of variance procedure was used. Comparisons within the normal group (F = 2.46, df = 2,27, NS), right brain-damaged group (F = 0.428, df = 2,27, NS), fluent aphasic group (F = 0.128, df = 2,27, NS), as well as within the non-fluent aphasic group (F = 0.16, df = 2,27, NS) showed no significant differences. This suggested that no subject group suffered a detrimental effect upon retention from increasing lengths of response delay when undistracted and each should retain all the information initially encoded for at least 18 seconds.

When distracted, non-brain-damaged subjects (F = 3.21, df = 2,27, NS), right brain-damaged subjects (F = 1.78, df = 2,27, NS), and non-fluent aphasic subjects (F = 3.21, df = 2,27, NS) showed no significant difference over time, as determined by a one-way analysis of variance. The fluent aphasic subjects did show a significant difference ($F = 4.70$, $df = 2,27$, $p < 0.05$) in accuracy scores at 3, 9, and 18 seconds. It would appear, therefore, that the accuracy of the performance of fluent aphasic subjects suffered a detrimental effect from increases in the response delay. It should be noted, however, that the analysis of information retention during the first three seconds showed that the right brain-damaged group ($t = 3.62$, $df = 18$, $p < 0.005$) and the non-brain-damaged group ($t = 3.73$, $df = 18$, $p < 0.005$) lost a significant amount of information. Therefore, the non-fluent aphasic group was the only group to remain unaffected by response delay, whether at 3 seconds, 9 seconds, or 18 seconds.

Counting Productivity

Counting productivity is assessed by computing the quantity of numbers produced by the subject on the counting distractor task during the test. See Appendix L for the number of digits spoken by each subject. Table 7 contains means, standard deviations, and ranges of each of the four subject groups. A one-way analysis of variance was performed and showed no significant differences between the subject groups on counting productivity ($F = 1.02$, $df = 3,36$, NS).

Neglect

The effect of neglect upon performance was evaluated by obtaining the sums of responses produced on the right side or

Table 7

Counting Productivity

	SUBJECT GROUPS			
	NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
MEANS	54.5	49.4	38.5	42.7
STANDARD DEVIATIONS	13.28	15.7	32.43	20.47
RANGES	25-81	28-81	18-128	27-96

left side of the page. Tables 8 - 11 contain these sums for each individual as well as means, standard deviations, and ranges for each subject group.

The largest discrepancy in the scores on the right versus the left side of the page in the normal subject group is 12. Using 12 or less as the normal range of difference between the 2 scores, 5 brain-damaged subjects can be identified as showing a preference for one side of the page. Three subjects in the right brain-damaged group (subjects 1, 5, and 6) show a propensity to respond on the right side of the page while one non-fluent aphasic subject (subject 6) prefers the left side of the page and another non-fluent aphasic subject (subject 7) prefers the right.

The performance of each subject group on the right side of the page was compared to their performance on the left side of the page. Two-sample t-tests were performed and the only group that had a significant difference ($t = 3.10$, $df = 18$, $p < 0.01$) was the right brain-damaged group which showed a propensity to respond to the right side of the page. Normal subjects ($t = 0.511$, $df = 18$, NS), non-fluent aphasic subjects ($t = 0.620$, $df = 18$, NS), and fluent aphasic subjects ($t = 1.45$, $df = 18$, NS) did not show significant differences in the number of responses on each side of the page.

Sequence Position of Error Items

Each trial consisted of the presentation of a sequence of three nouns. Position within the sequence of error

Table 8

Number of Responses on Each Side of the Response Page by Normal Subjects

SUBJECT NUMBER	SIDE OF THE RESPONSE PAGE	
	LEFT	RIGHT
1	40	44
2	41	43
3	45	39
4	44	40
5	43	41
6	40	44
7	38	46
8	36	48
9	48	36
10	41	43
MEANS	41.6	42.4
STANDARD DEVIATIONS	3.5	3.5
RANGES	36-48	36-48

Table 9

Number of Responses on Each Side of the Response Page by Right Brain-Damaged Subjects

SUBJECTS NUMBER	SIDE OF THE RESPONSE PAGE	
	LEFT	RIGHT
1	30	54
2	45	39
3	42	42
4	41	43
5	32	52
6	34	50
7	39	45
8	42	42
9	40	44
10	41	43
MEANS	38.6	45.4
STANDARD DEVIATIONS	4.9	4.9
RANGES	30-45	39-54

Table 10

Number of Responses on Each Side of the Response Page by Fluent Aphasic Subjects

SUBJECT NUMBER	SIDE OF THE RESPONSE PAGE LEFT	RIGHT
1	43	41
2	40	44
3	40	44
4	40	44
5	45	39
6	42	42
7	45	39
8	44	40
9	44	40
10	40	44
MEANS	42.3	41.7
STANDARD DEVIATIONS	2.16	2.16
RANGES	40-45	39-44

Table 11

Number of Responses on Each Side of the Response Page by Non-Fluent Aphasic Subjects

SUBJECT NUMBER	SIDE OF THE RESPONSE PAGE	
	LEFT	RIGHT
1	47	37
2	43	41
3	45	39
4	45	39
5	45	49
6	56	28
7	32	52
8	40	44
9	47	37
10	40	44
MEANS	44.0	40.0
STANDARD DEVIATIONS	6.16	6.16
RANGES	32-56	28-52

responses was evaluated among subject groups. See Appendix M for the number of errors occurring in each sequence position for each individual. Means, standard deviations, and ranges for each group are included in Table 12. Normal subjects, right brain-damaged subjects, and non-fluent aphasic subjects made more errors retaining the final items than the medial or initial items respectively. The fluent aphasic subjects made most of their errors retaining medial items. As with the other subject groups, fluent aphasics made fewer errors on initial items.

Statistical significance was evaluated by performing an analysis of variance in which position, group, and subject nested within group indicating an interaction between group and position ($F = 1.34$, $df = 6,72$, NS). Therefore, position was analyzed across groups and a significant difference in position was noted ($F = 7.28$, $df = 2,72$, $p < 0.01$). A Duncan's multiple range procedure (Steel & Torrie, 1960) was performed at the 0.05 level of significance which indicated that items in the initial position were more often identified than items in the medial or final position. The number of errors on items in the medial versus final position were not significantly different.

The Effect of Test Length Upon Performance

The effect of test length upon performance was evaluated by comparing the mean item accuracy of each subject group's performance on trials 1 - 14 with performance on items on

Table 12

Sequence Position of Error Responses

SUBJECT GROUPS		ERROR[a] POSITION INITIAL	MEDIAL	FINAL
NORMAL SUBJECTS	MEANS	2.3	3.3	4.5
	STANDARD DEVIATIONS	1.89	2.71	2.37
	RANGES	0-6	0-7	2-10
RIGHT BRAIN-DAMAGED SUBJECTS	MEANS	3.9	5.2	8.1
	STANDARD DEVIATIONS	2.77	2.94	4.51
	RANGES	1-10	1-11	2-15
FLUENT APHASIC SUBJECTS	MEANS	8.9	11.3	10.2
	STANDARD DEVIATIONS	5.7	5.29	3.91
	RANGES	1-19	3-23	4-16
NON-FLUENT APHASIC SUBJECTS	MEANS	14.1	15.1	15.9
	STANDARD DEVIATIONS	6.62	4.89	4.68
	RANGES	4-24	5-23	9-23

ERROR[a]: Total possible = 28.

trials 15 - 28. Since order of presentation of experimental conditions was counterbalanced within subject groups, no allowances needed to be made for condition in this analysis. See Appendix N for first half-test and second half-test performance for each subject. Means, standard deviations, and ranges of each subject group are included in Table 13. The difference between first and second half were very minimal, the greatest being a 1.3 item difference. A two-way analysis of variance indicated that there was no evidence of any group getting significantly worse or significantly better as the test progressed ($F = 0.02$, $df = 1,36$, NS).

Independent Measures

The severity of the language disturbances of the fluent aphasia group and non-fluent aphasia group were compared. The overall mean scores of the Porch Index of Communicative Ability for each group were computed and a random t-test was administered. Fluent aphasics obtained significantly higher scores on this test than did the non-fluent aphasic subjects ($t = 1.76$, $df = 18$, $p < 0.05$). Also, the severity of the auditory comprehension deficit of the fluent aphasia group was compared to that of the non-fluent aphasia group. The mean number correct for each group was obtained and a random t-test was administered. The scores of the fluent aphasic subjects were significantly higher than the scores of the non-fluent aphasic subjects ($t = 2.51$, $df = 18$, $p < 0.01$).

Table 13

Performance Over the Course of the Test
First Half Versus Second Half

SUBJECTS GROUPS		PERFORMANCE[a] FIRST HALF-TEST	SECOND HALF-TEST
NORMAL SUBJECTS	MEANS	36.3	37.6
	STANDARD DEVIATIONS	5.1	5.06
	RANGES	25-41	27-42
RIGHT BRAIN-DAMAGED SUBJECTS	MEANS	33.0	33.8
	STANDARD DEVIATIONS	5.48	7.99
	RANGES	25-41	21-42
FLUENT APHASIC SUBJECTS	MEANS	26.8	26.8
	STANDARD DEVIATIONS	8.52	7.15
	RANGES	13-40	16-41
NON-FLUENT APHASIC SUBJECTS	MEANS	19.8	19.1
	STANDARD DEVIATIONS	8.47	6.56
	RANGES	9-37	9-29

PERFORMANCE[a]: Total possible = 42.

Correlation Analysis

Initial Encoding and Severity of Aphasia

To determine the relationship between the initial encoding scores of each aphasic subject with the severity of aphasia as measured by the overall mean score on the Porch Index of Communicative Ability (Porch, 1967) a Pearson product moment correlation coefficient procedure was computed and a significant correlation was noted ($r = 0.60$, $p < 0.01$).

Initial Encoding and Severity of Auditory Comprehension Deficit

The relationship of the initial encoding scores of each aphasic subject with the severity of the auditory comprehension deficit as measured by their performance on the Token Test (DeRenzi & Vignolo, 1962) was investigated. Again the Pearson product moment correlation coefficient procedure was used. Results indicate a significant correlation between the amount of information initially encoded and the degree of auditory comprehension deficit ($r = 0.43$, $p < 0.05$).

The Amount of Information Lost When Distracted and the Severity of Aphasia

The amount of information lost by distraction was measured by comparing the amount of information retained when undistracted at 3, 9, and 18 seconds collectively with that retained when distracted. A percentage of loss in each subject was obtained by subtracting the total when distracted from the total when undistracted and then dividing by the total when undistracted. Each aphasic subject was ranked according to the degree of information lost as measured by the percentage of loss. Each aphasic subject was also ranked according to severity of aphasia as measured by Porch Index of Communicative Ability (Porch, 1967) overall mean score. A Spearman rank-difference correlation procedure was performed. No significant correlation was obtained between the severity of aphasia and the amount of information lost when distracted (rho = 0.427, NS), but it should be noted that a correlation coefficient of 0.450 would be significant ($p < 0.05$).

The Amount of Information Lost When Distracted and the Severity of Auditory Comprehension Deficit

The percentage of information loss established previously was again used as a measure of the amount of information lost by each subject when distracted. Each aphasic subject was ranked according to the degree of information loss as well as ranked according to the severity of their auditory comprehension deficit as measured by performance on the Token Test (DeRenzi & Vignolo, 1962). A Spearman rank-difference correlation procedure was performed. A significant correlation was noted between the severity of the auditory comprehension deficit and the amount of information lost when distracted (rho = 0.708, $p < 0.01$).

Summary of Results

The preceding analyses are summarized below.

1. The normal group and right brain-damaged group did not differ in the totals of items retained throughout the test, regardless of experimental condition. Aphasic groups differed significantly from the control groups as well as differed significantly from one another in total item retention. In general, the non-fluent aphasic group retained significantly fewer items than all other subject groups, followed by the fluent aphasic group which also differed significantly from all other subject groups.

2. The aphasic subjects also encoded significantly less information initially than the right brain-damaged group or the normal group. The non-fluent aphasic group encoded significantly less than the fluent aphasic group while the right brain-damaged group encoded significantly less than the normal group.

3. The fluent aphasic group was the only subject group to show, when distracted, a significant rate of information loss during the retention interval beginning after three seconds.

4. The normal and right brain-damaged group, when distracted, lost a significant amount of information before the response at three seconds while the fluent aphasic and non-fluent aphasic groups did not.

5. Comparisons between the amount of information maintained at three seconds when distracted and when not distracted showed that normal and right brain-damaged subject groups lost a significant amount of information when they were distracted but fluent aphasic and non-fluent aphasic groups did not.

6. Comparisons between the amount of information maintained at nine seconds when distracted and when not distracted showed that normal, right brain-damaged, and fluent aphasic groups lost a significant amount of information when they were distracted but the non-fluent aphasic group did not.

7. Comparisons between the amount of information maintained at 18 seconds when distracted and when not distracted showed that the normal, right brain-damaged, and fluent aphasic groups lost a significant amount of information when they were distracted but non-fluent aphasic subjects did not.

8. No subject group lost any significant amount of information after 18 seconds when undistracted.

9. The fluent aphasic, right brain-damaged, and normal groups lost a significant amount of information after 18 seconds when distracted. The non-fluent aphasic group did not.

10. None of the subject groups showed significant differences on counting productivity during the test.

11. The fluent aphasic, non-fluent aphasic, and normal groups showed no significant propensity to respond on one

side of the response page rather than the other. The right brain-damaged group did show a significant preference for responding on the right side of the page.

12. All subject groups retained significantly more items presented on the initial sequence position than medial or final position. No significant differences between medial or final position were noted. No significant differences were noted between subject groups.

13. No subject group got significantly more accurate or less accurate as the test progressed.

14. A significant correlation existed between overall mean scores on the Porch Index of Communicative Ability (Porch, 1967) and initial encoding scores in aphasic subjects.

15. A significant correlation was found between Token Test (DeRenzi & Vignolo, 1962) scores and initial encoding scores in aphasic subjects.

16. No significant correlation was found between the overall mean scores on the Porch Index of Communicative Ability (Porch, 1967) and the amount of information lost when distracted in aphasic subjects.

17. There was a significant correlation between the Token Test (DeRenzi & Vignolo, 1962) scores and the amount of information lost when distracted in aphasic subjects.

From the findings of the present study, the following conclusions were made concerning the eight hypotheses proposed.

1. Hypothesis #1 was supported by result #1.
2. Hypothesis #2 was supported by result #2.
3. Hypothesis #3 was supported by result #2.
4. Hypothesis #4 was not supported by result #8.
5. Hypothesis #5 was supported by result #8.
6. Hypothesis #6 was supported by results #4, 5, 6, 7, 9.
7. Hypothesis #7 was supported by results #3, 5, 6, 7, 9.
8. The portion of hypothesis #8 dealing with the correlation between performance on the _Porch Index of Communicative Ability_ (Porch, 1967) and the amount of information loss with distraction was not supported by result #16.
9. The portion of hypothesis #8 dealing with the correlation between performance on the _Token Test_ (DeRenzi & Vignolo, 1962) and amount of information loss with distraction was supported by result #17.

CHAPTER IV
DISCUSSION AND IMPLICATIONS

Discussion

Human information processing is a complex system which is constructed in keeping with its structural constraints and operated upon by its control processes. Milner (1962) suggests that in conjunction with brain lesions that result in aphasia is a high incidence of memory dysfunction for verbally encoded information. The nature of the relationship between aphasia and verbal memory remains elusive. A limited amount of information concerning the integrity of the structural constraints and control processes of the verbal information processing system of aphasic individuals is known, however. The structural constraints of limited span (DeRenzi & Nichelli, 1975; Heilman et al., 1976; Flowers, 1973b; Albert, 1972; Goodglass et al., 1970; Kim, 1976; Saffran et al., 1977) and the normal influence of proactive interference (Flowers, 1975) in aphasic subjects represent some of the current knowledge. Regarding control processes, Locke and Deck (1978) found that word retrieval difficulties have a negative effect upon rehearsal while Heilman, Scholes, and Watson (1976) suggest a link between repetition deficits and rehearsal deficits. A question remains as to whether or not aphasic subjects perform a self-terminating (Swinney & Taylor, 1971) or exhaustive (Warren, 1975) memory search.

Total Item Retention

A tabulation of all correct responses for each subject allowed a measurement of the amount of information processed during all experimental conditions combined. Statistical analysis showed that the normal and right brain-damaged subjects did not differ significantly in the total number of items retained but the aphasic subjects did. Non-fluent aphasic subjects processed less information than fluent aphasic subjects, and both groups differed from the right brain-damaged subjects and normal subjects.

Qualitative and quantitative differences in information processing may have resulted in the differential seen between subject groups on Total Item Retention, and it was necessary to examine both of these possibilities.

Initial Encoding

An examination of the quantitative differences in the information processing of the subject group was achieved by measuring the amount of information initially encoded, without contaminating the results with experimental conditions of response delay or distraction. Comparisons between subject groups of initial encoding showed that all of the groups were significantly different from one another with normal subjects encoding the most, followed by right brain-damaged subjects, fluent aphasic subjects, and non-fluent aphasic subjects respectively. A possible explanation for the finding that the right brain-damaged subjects were lower than the normal subjects on initial encoding scores shall be discussed in a later section. The effect of aphasia, however, upon initial encoding was statistically significant. The correlation of severity of aphasia as well as severity of auditory comprehension dysfunctioning to initial encoding scores was also significant. In summary, the aphasic subjects, especially the more severe aphasic subjects, began the retention task with less information in primary than control subjects and therefore had less information to lose. This finding is consistent with the encoding ability of aphasic subjects found by Butter, Samuels, Goodglass, and Brody (1970).

Information Retention

Examination of the qualitative differences in the information processing of the subject groups was achieved by evaluating the effect that distraction had upon retention performance over an interval of 18 seconds. By visual inspection of the lines representing performance with and without distraction, it was possible to make inferences about the integrity of the control process of rehearsal in fluent aphasic subjects, non-fluent aphasic subjects, and right brain-damaged subjects.

Statistical analysis showed that the normal group suffered a significant amount of information loss with distraction. In fact, the normal group lost a significant amount of information when distracted very early in the retention interval (before the earliest recall measurement at three seconds). When left undistracted, the normal subjects were able to maintain the information in entirety. This detrimental effect of distraction suggests that the distraction interfered with the retention of the verbal information. The inference here is that these normal subjects rehearsed the items to be maintained when undistracted and were prevented from doing so when distracted. The interference of the content of the distractor task upon the stimulus items is also possible since both are verbal-linguistic in nature.

The distraction task resulted in a similar significant decrement in performance as compared to performance when undistracted in the right brain-damaged group. Neglect was found to have affected the performance of some subjects in the right brain-damaged group as well. The group responded significantly more often on the right side than the left side of the page while normal subjects, fluent aphasic subjects, and non-fluent aphasic subjects responded on both sides of the page equally often. Since each subject's performance when distracted was compared to his performance when not distracted, results concerning the presence of rehearsal among right brain-damaged subjects should remain unaffected by neglect. Therefore, it can be concluded that the right brain-damaged group retains verbal information by the control process of rehearsal, just as the normal group does.

The fluent aphasic subjects showed a detrimental effect of distraction upon retention similar to that of the normal and right brain-damaged groups except that this effect was not significant until the retention measurement at nine seconds. The inference again is that these fluent aphasic subjects perform the same control process, rehearsal, as do the normal and right brain-damaged subjects. Therefore, no qualitative differences exist between these three groups on retention of verbal information. The question remains, however, as to the reason for the delay in the effect of the distraction task until the three to nine second interval in the fluent aphasic group as compared to the control group.

A qualitative difference from the other subject groups in information processing is noted in the fluent aphasic group. These subjects showed performance when distracted that was not significantly different from performance when not distracted. This suggests that these subjects do not spontaneously employ rehearsal as a control process for retention of verbal information. Since these subjects performed the poorest of all groups, there is the possibility that this is a reflection of a quantitative difference between subject groups. It should be noted, once again, that the presence or absence of rehearsal in any subject group was established by using each group as its own control. Also, since no group's performance at any point approximated that which could be expected by chance (30 out of 120) nor perfect performance (120), the effect of quantiative differences in performance between groups does not account for the qualitative difference in performance between the non-fluent aphasic group and the groups of fluent aphasic subjects, right brain-damaged subjects, and normal subjects.

As did the other subject groups, the non-fluent aphasic group showed no significant loss of information when undistracted as the time interval progressed. This suggests that although they are only able to process a limited amount of information at any time, that which is encoded is retained.

Since the non-fluent aphasic group included subjects whose aphasia was significantly more severe than the fluent aphasic group, the qualitative difference seen in the retention of verbal information may be a reflection of a quantitative difference in aphasia rather than a qualitative difference. Statistical analysis showed, however, that there was no significant correlation between the severity of aphasia and the effectiveness of the distractor task. Therefore, this lack of rehearsal in the non-fluent aphasic group cannot be accounted for by the severity of aphasia. It is interesting to note, here, that auditory comprehension ability was significantly correlated with the effectiveness of the distractor task. The implication of this would be that the ability to retain limited amounts of verbal information is somehow related to the ability to comprehend the meaning of a message presented auditorily. The nature of the relationship remains unknown.

Another possible explanation for the differential in the use of rehearsal as a control process may be that one group, specifically the non-fluent aphasic group, was more susceptible to fatigue than the other subject groups. Statistical analysis showed, however, that no group performed worse as the test progressed.

In summary, one hypothesis of this study was that left brain-damaged subjects (aphasic subjects) would retain, in all experimental conditions, fewer items than the control subjects. This hypothesis was supported by the findings of the present study and is consistent with the proposal of Milner (1962) that left brain damage results in a higher incidence of disorders of primary memory for verbal information than does right brain damage. This result was influenced by both quantitative and qualitative differences in the information processing of the subject groups. The aphasic subjects showed quantitative differences from the control subjects in the amount of information they initially encoded into the memory system. This result also supported the hypothesis of this study.

The differential effects of a distractor task upon retention of verbal information allowed examination of the qualitative differences of the information processing of the subject groups. The non-fluent aphasic subjects did not rehearse information in order to maintain it in primary memory while normal subjects, right brain-damaged subjects, and fluent aphasic subjects did. These results also supported the hypotheses of the present study.

The findings of the present study are also in agreement with the basic finding of Locke and Deck (1978) and the suggestion of Heilman et al. (1976) that the aphasic subjects who display difficulties with verbal output also do not effectively rehearse verbal information on a retention task. However, Heilman et al. (1976) suggest that this rehearsal difficulty is linked to a repetition deficit rather than a fluency deficit while Locke and Deck (1978) suggest that the relationship is between word retrieval abilities and rehearsal. The suggestion of Flowers (1975) that "recall problems in aphasics" (p. 49) when distracted may be due to an excessive rate of information loss was not supported by the present study.

A significant correlation between severity of auditory comprehension dysfunctioning in aphasic subjects and the amount of information lost when distracted supported the hypothesis of the present study. The lack of a significant correlation between severity of aphasia and the amount of information lost when distracted, however, did not.

Counting Productivity

The quantity of numbers produced on the counting distractor task by each individual was tabulated and group scores were calculated. Since the distractor task has a variable level of difficulty dependent upon the proficiency of the subject, counting productivity was thought to allow a comparison of the relative difficulty of the distractor task for each subject group. Statistical analysis showed no significant differences between subject groups. This suggests that although the level of difficulty was variable, the relative difficulty of the distractor task was equal for all subject groups and therefore retention performance differences cannot be attributed to a differential in distractor task difficulty.

Inherent in the definition of the fluent/non-fluent distinction of aphasia is the notion that non-fluent aphasic individuals generate less output than fluent aphasic individuals. When examining the content of the distractor tasks, it should be noted that the majority of the fluent aphasic subjects qualified on the counting proficiency task to perform the more difficult counting tasks while the majority of non-fluent aphasic subjects qualified for the easier counting tasks. Therefore comparisons between the fluent and non-fluent aphasic groups of the quantity of verbal output on the distractor tasks is not possible.

Sequence Position of Error Items

The presence of brain damage or aphasia had no effect upon the position of error items. Although brain-damaged subjects,especially those with aphasia, made significantly more errors in general, the position of the items most likely to be retained was the initial item presented in the sequence regardless of subject group. The medial and final items were equally likely to be lost, regardless of subject group. Therefore, the aphasic subjects were no different from control subjects as to which items they lost, just how much was lost.

Implications for Future Research

Considering the abundance of knowledge on the information processing systems of normal human adults, very little is known about these systems in individuals with aphasia. Research concerning the control processes as well as structural constraints of both the primary and secondary memory of aphasic subjects is needed. With the enormity of this task recognized, this discussion shall be limited to the implications of the findings of this particular study.

A number of questions arise from the results of the present study. One central problem is to account for the qualitative differences in the information processing performance of non-fluent aphasic subjects when compared to fluent aphasic subjects, non-aphasic brain-damaged subjects (right brain-damaged), or non-brain-damaged subjects (normals). Accepting the hypothesis that information stored in primary memory is acoustic in nature (Conrad, 1964, 1967; Estes, 1972, 1973; Wickelgren, 1965) while information stored in secondary memory is semantic in nature (Anisfeld & Knapp, 1968; Baddeley, 1966; Grossman & Eagle, 1970), coding differences between groups could be analyzed by manipulations of response possibilities. In this study, the response page could have contained not only the target stimuli but also items which were semantically associated or acoustically similar to the target stimuli. An analysis of error responses of non-fluent aphasic subjects might show a preponderance for semantic errors suggesting that their poor performance resulted from directly encoding into secondary memory, bypassing primary memory. It is proposed that storage of information into secondary memory is much slower than storage into primary memory and in this study the time constraints could have resulted in a reduction of information encoded into the memory system. Information stored in secondary memory by non-fluent aphasic individuals would be resistant to distraction, as found in this study. But the question arises whether or not the secondary memory system is also disturbed in aphasic subjects. Because aphasic subjects were generally assisted by the semantic relatedness of words in the Flowers (1973b) study (especially when word lists were under six items in length) and because Flowers (1975) found in the study on proactive interference that aphasic subjects were as sensitive to changes in stimulus content as control subjects, it might be concluded that semantically coded secondary memory continues to perform efficiently in aphasic subjects. Further investigation into the secondary memory processing of aphasic subjects is necessary, however.

The poorer performance of aphasic subjects on the retention task in general, as compared to the non-aphasic subjects, could result from two possible problems. One is that the aphasic subjects were employing a poorly functioning verbal-linguistic processing system to code the target stimuli (that is, the injured left hemisphere). Another possibility would be that the aphasic subjects employed an inefficient or inexperienced visual-spatial system (that is, the right hemisphere) to code the items. The differential effects of differing distractor task contents would distinguish between these possible explanations.

Regarding initial encoding, the aphasic subjects in the present study may have performed poorer than non-aphasic subjects because the target stimuli were presented only in the auditory modality. Presentation of the stimuli in the visual modality would allow an examination of the influence of input modality on the initial encoding performance of the aphasic subjects.

The findings of this study also raise a number of questions that represent an extension into clinical implications. The ability to manipulate rehearsal in an aphasic individual needs to be examined. For example, would it be possible to increase retention by instructing the subject to rehearse the stimuli before responding? The effectiveness of alternate strategies such as visual imagery proposed by Seamon (1974), West (1977), and Martin and West (West, Helm, & Martin, 1977) should also be experimentally explored. The subsequently emerging question would be whether increasing retention proficiency in these experimental tasks using either technique proposed would result in better auditory comprehension or better verbal repetition, as measured by some clinical tool.

In summary, a number of questions need to be investigated concerning explanations of qualitative and quantitative differences in retention of verbal information between aphasic and non-aphasic subjects. The clinical extension of the findings of this study result in questions concerning the manipulability of the control process of rehearsal and the result that such manipulations would have upon auditory comprehension or verbal output.

Implications for Clinical Intervention

Until the answers to the questions in the preceding section are obtained, the rationale for an intervention program for a deficient rehearsal control process in an aphasic individual would not be experimentally supported. However, establishing the integrity of this process in each individual would allow a clinician to be economical in selection of techniques for treatment of other deficient verbal behaviors.

Summary and Conclusions

In the present study non-fluent aphasic subjects and fluent aphasic subjects were compared with right brain-damaged subjects and non-brain-damaged subjects on a task which allowed the analysis of information processes involved in the retention of verbal information. The subjects were presented 3 nouns auditorily and asked to respond via a recognition paradigm (pointing) immediately after the presentation or after a 3, 9, or 18 second response delay. During this response delay the subjects were distracted by a verbal counting task or left undistracted. The initial encoding responses, those obtained immediately after presentation, were tabulated for each group and compared across groups. Comparisons of performance when distracted with performance when not distracted for each subject group yielded results indicating the presence of rehearsal as a strategy for maintenance of information in primary verbal memory. These analyses yielded the following main conclusions.

1. Aphasic subjects retained fewer items in all experimental conditions of this primary verbal memory task than did non-aphasic brain-damaged subjects (right brain-damaged subjects) or non-brain-damaged subjects (normal subjects). This may be indicative of a primary memory deficit for verbal information. However, due to the nature of the aphasia syndrome, depressed scores may have resulted from poor comprehension of the items to begin with.

2. Aphasic subjects initially encoded significantly less information into the memory system than did non-aphasic brain-damaged subjects or non-brain-damaged subjects. Non-fluent aphasic subjects initially encoded the least information followed by fluent aphasic subjects and right brain-damaged subjects respectively. All group comparisons were significant. No group performance equaled chance (30) or perfection (120). Therefore, part of the explanation for the depressed scores in all experimental conditions was the result of initially encoding less information.

3. The non-fluent aphasic group performed qualitatively different on the retention task than did the fluent aphasic subjects, right brain-damaged subjects, or

non-brain-damaged subjects. It appeared as though these non-fluent aphasic subjects did not rehearse the verbal information while all other subject groups did. Therefore, a specific information processing disorder was noted in the non-fluent aphasic subjects.

Although this study yields no information concerning the nature of the relationship between the syndrome of aphasia and memory dysfunction, it does confirm the incidence of a memory dysfunction in patients suffering brain damage that resulted in non-fluent aphasia. It is hoped that this information in conjunction with that obtained from future research on the information processing of aphasic individuals will be used to better direct the focus and methodologies of each patient's language intervention process.

APPENDIX A

Subject Information

APPENDIX A-1

Subject Information Fluent Aphasic Group

SUBJECT	AGE	EDUCATION	MONTHS POST-ONSET	APHASIA TYPE	RIGHT HEMI-PARESIS	PICA OVERALL PERCENTILE	TOKEN TEST SCORE (%)	ETHANOL ABUSE	ETIOLOGY	LESION CONFIRMATION
1	53	12	29	WERNICKES	+	56	17.5	-	CVA	-
2	62	10	4	TRANS-CORTICAL SENSORY	+	49	45	-	CVA	EEG BRAIN SCAN
3	60	11	3	WERNICKES	-	71	35	-	CVA	-
4	58	12	8	-	+	48	20	-	CVA	-
5	59	17	8	-	+	92	62.5	-	CVA	EEG
6	37	12	15	-	+	86	50	+	TRAUMA	EEG
7	54	0	1	GLOBAL	-	42	32.5	-	CVA	-
8	66	4	2	ANOMIA	+	29	27.5	+	CVA	-
9	62	6	15	CONDUCTION	-	71	32.5	+	CVA	EEG
10	66	7	22	CONDUCTION	+	58	62.5	-	CVA	EEG

APPENDIX A-2

Subject Information Non-Fluent Aphasic Group

SUBJECT	AGE	EDUCA-TION	MONTHS POST ONSET	APHASIA TYPE	RIGHT HEMI-PARESIS	PICA OVERALL PERCENTILE	TOKEN TEST SCORE (%)	ETHANOL ABUSE	ETI-OLOGY	LESION CONFIR-MATION
1	63	8	2	BROCA'S	-	41	10	-	CVA	EEG BRAIN SCAN
2	52	14	18	BROCA'S	+	44	20	+	CVA	-
3	62	12	24	BROCA'S	+	53	47.5	-	CVA	-
4	54	8	2	BROCA'S	+	50	10	-	CVA	-
5	40	12	2	BROCA'S	+	59	50	-	CVA	EEG BRAIN SCAN
6	44	14	45	-	+	67	22.5	-	CVA	EEG
7	67	10	22	CONDUCTION	+	47	22.5	+	CVA	EEG BRAIN SCAN
8	65	14	33	-	+	44	15	+	CVA	
9	62	12	3	GLOBAL	+	17	0	-	CVA	EEG BRAIN SCAN
10	55	9	35	-	+	34	5	+	CVA	-

Note to Appendices A-1 and A-2:

Notations of aphasic type were made by members of the Neurology Service of the Gainesville Veterans Administration Hospital. A diagnosis of conduction aphasia was determined solely by repetition disability in relation to verbal output. Therefore, although Goodglass and Kaplan (1972) suggest that conduction aphasic subjects are generally fluent, one member of the non-fluent aphasic group was diagnosed as displaying conduction aphasia.

APPENDIX A-3

Subject Information Right Brain-Damaged Group

SUBJECT	AGE	EDUCATION	MONTHS POST-ONSET	LEFT HEMIPARESIS	NEGLECT	ETHANOL ABUSE	ETIOLOGY	LESION CONFIRMATION
1	64	12	2	+	+	-	CVA	-
2	53	6	1	+	+	+	CVA	EEG
3	70	12	1	+	-	-	CVA	BRAIN SCAN
4	53	6	1	+	-	-	CVA	BRAIN SCAN
5	46	6	2	-	-	-	CVA	BRAIN SCAN
6	57	8	1	+	-	-	CVA	EEG
7	60	5	1	-	-	-	CVA	-
8	58	19	24	+	-	-	CVA	-
9	65	4	1	+	-	-	CVA	-
10	72	14	39	+	-	-	CVA	-

APPENDIX A-4

Subject Information Normal Group

SUBJECT	AGE	EDUCATION	DIAGNOSIS	ETHANOL ABUSE
1	32	12	Stuttering	-
2	65	12	Upper Gastrointestinal Bleed	+
3	52	9	Cardiac Catheterization due to Angina	-
4	65	12	Echo Cardiogram	-
5	58	15	Cancer Gallbladder	-
6	48	16	Articulation Disorder Resulting From Gingival Surgery	-
7	75	14	Bacterial Endocarditis	-
8	63	12	Abdominal Pain Unknown Origin	-
9	63	12	Cardiac Catherization	-
10	31	8	Myocardial Infarction	-

APPENDIX B

Target Stimuli Frequency of Occurrence (Jones & Wepman, 1966)

STIMULUS	n[a]	MEAN[b]	STANDARD DEVIATIONS
bag	5	.35	1.205
bell	4	.74	3.488
bird	12	2.61	7.862
boat	18	2.87	6.054
book	41	7.44	6.814
boy	43	11.81	13.825
car	13	1.85	4.743
chair	7	.62	1.828
dog	4	.38	1.500
duck	3	.53	2.735
fence	11	1.62	3.710
flowers	17	2.53	5.696
gun	19	3.31	5.602
hand	46	16.40	15.134
hat	16	1.87	3.548
house	37	7.09	7.935
lamp	14	1.87	3.803
leaf	4	.33	1.419
pin	3	.33	1.468
shoe	5	.46	1.531
snake	11	1.40	3.372

APPENDIX B - continued

STIMULUS	n[a]	MEAN[b]	STANDARD DEVIATIONS
sun	18	2.18	3.522
table	26	4.38	7.367
tie	3	.42	2.007
tree	36	6.22	6.910
window	48	10.81	8.030

n[a]: Number of subjects in the Jones and Wepman (1966) study that used the word.

MEAN[b]: Mean number of occurrences per 10,000 consecutive words.

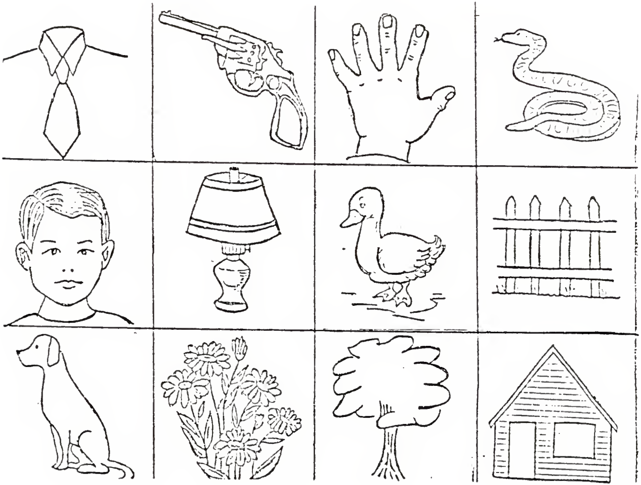
APPENDIX C

Target Stimuli Strings

1.	sun	boat	bell
2.	bag	duck	tree
3.	chair	leaf	shoe
4.	car	house	flowers
5.	hat	bird	lamp
6.	window	gun	fence
7.	book	leaf	tie
8.	lamp	bird	tree
9.	table	duck	shoe
10.	boy	house	pin
11.	sun	dog	lamp
12.	bag	hand	fence
13.	house	bell	book
14.	car	shoe	pin
15.	window	snake	tie
16.	bird	boat	tree
17.	book	house	chair
18.	table	hand	fence
19.	car	dog	flowers
20.	leaf	shoe	gun
21.	sun	duck	tie
22.	boy	duck	pin
23.	hat	snake	gun
24.	table	bell	tree
25.	chair	window	boat
26.	book	hat	flowers
27.	dog	bag	pin
28.	boy	hand	snake

APPENDIX D

An Example of the Response Page



APPENDIX E

Experimental Conditions Presentation Order

	EXPERIMENTAL CONDITION[a]			EXPERIMENTAL CONDITION	
TRIAL	ORDER A	ORDER B	TRIAL	ORDER A	ORDER B
1	2	6	15	7	1
2	1	7	16	6	2
3	1	7	17	7	1
4	3	5	18	5	3
5	3	5	19	6	2
6	2	6	20	6	2
7	2	6	21	6	2
8	1	7	22	7	1
9	3	5	23	5	3
10	1	7	24	5	3
11	4	4	25	4	4
12	3	5	26	5	3
13	2	6	27	4	4
14	4	4	28	7	1

EXPERIMENTAL CONDITION[a]:

1 = 18 second delay + distractor task
2 = 9 second delay + distractor task
3 = 3 second delay + distractor task
4 = 0 second delay (immediate report)
5 = 3 second delay + no distractor task
6 = 9 second delay + no distractor task
7 = 18 second delay + no distractor task

APPENDIX F

Counting Proficiency

APPENDIX F-1

Individual Counting Proficiency

		SUBJECT GROUPS			
	SUBJECT NUMBER	NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
COUNTING PROFICIENCY[a]	1	B3	B2	F1	F1
	2	B3	B3	B1	F1
	3	B3	B3	B2	F1
	4	B2	B3	F1	F1
	5	B3	F3	F3	B1
	6	B3	B2	B2	B2
	7	B2	B2	F1	B1
	8	B3	B3	B1	F1
	9	B3	B3	B3	F1
	10	B3	B3	B2	F1

COUNTING PROFICIENCY[a]:

B3 = counting backward by three,
B2 = counting backward by two,
B1 = counting backward by one,
F1 = counting forward by one,
F2 = counting forward by two,
F3 = counting forward by three.

APPENDIX F-2

Counting Proficiency Group Comparisons

COUNTING PROFICIENCY TASKS[a]	NUMBER OF SUBJECTS NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
B3	8	6	1	-
B2	2	3	3	1
B1	-	-	2	2
F3	-	1	1	-
F2	-	-	-	-
F1	-	-	3	7

COUNTING PROFICIENCY TASKS[a]:

B3 = counting backward by 3,
B2 = counting backward by 2,
B1 = counting backward by 1,
F3 = counting forward by 3
F2 = counting forward by 2,
F1 = counting forward by 1.

APPENDIX G

Two-Digit Numbers for Distraction Task

20	30	40	51	61	72	82	91
21	31	43	52	62	73	83	93
22	32	46	53	63	74	84	95
24	33	47	55	65	75	85	96
25	37	48	56	67	77	87	97
26	38	49	58	68	78	88	98

APPENDIX H

Score Sheet

1.	sun(1)	table	window	boat(2)
	bell(3)	chair	tree	book
	leaf	bag	hat	duck
2.	table	boat	car	book
	bag(1)	duck(2)	house	snake
	hand	pin	lamp	tree(3)
3.	sun	window	chair(1)	boat
	leaf(2)	bag	duck	house
	shoe(3)	gun	flowers	tree
4.	boat	table	tree	car(1)
	bag	book	hat	house(2)
	flowers(3)	bird	dog	chair
5.	bell	sun	tree	boat
	leaf	hat(1)	snake	shoe
	bird(2)	chair	flowers	lamp(3)
6.	car	window(1)	boy	leaf
	snake	house	gun(2)	bird
	flowers	fence(3)	pin	lamp

7.	boy	lamp(1)	tree(3)	boat
	snake	bird(2)	gun	dog
	bell	leaf	hat	sun

8.	flowers	lamp(1)	tree(3)	boat
	snake	bird(2)	gun	dog
	bell	leaf	hat	sun

9.	gun	table(1)	shoe(3)	pin
	sun	hand	bell	bag
	leaf	lamp	duck(2)	boy

10.	pin(3)	bag	gun	boy(1)
	window	duck	hand	table
	book	sun	house(2)	fence

11.	dog(2)	car	lamp(3)	tie
	bird	boat	sun(1)	snake
	table	book	hat	leaf

12.	house	snake	bag(1)	dog
	gun	hand(2)	shoe	duck
	tie	fence(3)	lamp	pin

13.	book(3)	shoe	lamp	hat
	bird	boy	hand	tie
	house(1)	bag	sun	bell(2)

14.	sun	snake	car(1)	window
	bird	house	leaf	bag
	shoe(2)	pin(3)	fence	table
15.	shoe	book	boat	bird
	window(1)	lamp	snake(2)	dog
	bell	gun	fence	tie(3)
16.	boat(2)	boy	chair	bird(1)
	leaf	car	bell	hat
	tree(3)	fence	window	book
17.	boat	bird	book(1)	gun
	sun	house(2)	car	snake
	hand	shoe	chair(3)	bell
18.	window	table(1)	dog	sun
	shoe	bird	boy	hat
	bag	bell	fence(3)	hand(2)
19.	bag	chair	dog(2)	lamp
	car(1)	leaf	flowers(3)	bird
	bell	hand	fence	tie
20.	pin	boy	hat	tie
	gun(3)	boat	shoe(2)	leaf(1)
	table	house	car	fence

21.	dog	tie(3)	fence	hat
	book	bell	lamp	sun(1)
	window	boy	shoe	duck(2)
22.	hand	tree	gun	book
	boat	flowers	pin(3)	chair
	car	boy(1)	tie	duck(2)
23.	window	car	pin	chair
	fence	book	leaf	gun(3)
	duck	hat(1)	tie	snake(2)
24.	chair	table(1)	duck	flowers
	tree(3)	hat	hand	bell(2)
	bag	shoe	pin	dog
25.	duck	tie	flowers	snake
	bag	car	pin	hand
	house	boat(3)	chair(1)	window(2)
26.	flowers(3)	bird	dog	house
	pin	hat(2)	tree	bell
	sun	window	book(1)	table
27.	snake	bag(2)	dog(1)	chair
	pin(3)	flowers	fence	tie
	tree	table	boy	bell

28.	tie	gun	hand(2)	snake(3)
	boy(1)	lamp	duck	fence
	dog	flowers	tree	house

TOTAL ERROR /84 = _____%

CORRECT WHILE DISTRACTED = _____/36

CORRECT WHILE NOT DISTRACTED = _____/36

CORRECT AT IMMEDIATE REPORT = _____/12

COUNTING PRODUCTIVITY = _____

APPENDIX I

Subject Scores on Independent Measures

APPENDIX I-1

Individual Overall Mean Scores
Porch Index of Communicative Ability

SUBJECT NUMBER	OVERALL MEAN SCORE FLUENT APHASIC SUBJECTS	 NON-FLUENT APHASIC SUBJECTS
1	11.18	9.1
2	10.51	9.97
3	12.21	10.92
4	10.41	10.66
5	13.96	11.38
6	13.37	11.69
7	9.74	10.28
8	8.31	9.92
9	12.22	6.87
10	11.31	8.86

APPENDIX I-2

Individual *Token Test* Performance

SUBJECT NUMBER	SCORE[a] FLUENT APHASIC SUBJECTS	 NON-FLUENT APHASIC SUBJECTS
1	7	4
2	19	8
3	14	19
4	8	4
5	25	20
6	20	9
7	13	9
8	11	6
9	13	0
10	25	2

SCORE[a]: Total possible = 40.

APPENDIX J

Data for Analysis of Quantitative Differences Between Subject Groups in Information Processing

APPENDIX J-1

Total Item Retention

SUBJECT NUMBER	TOTAL ITEM RETENTION[a] NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
1	80	63	52	31
2	79	69	55	32
3	70	64	56	64
4	75	73	39	55
5	79	53	71	53
6	76	51	48	37
7	72	75	56	23
8	67	77	29	41
9	67	67	57	18
10	74	76	73	35

TOTAL ITEM RETENTION[a]: Total possible = 84.

APPENDIX J-2

Initial Encoding Scores

	INITIAL ENCODING SCORES[a]			
SUBJECT NUMBER	NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
1	12	11	6	3
2	12	11	9	6
3	11	11	10	11
4	12	12	9	8
5	12	11	12	8
6	11	10	8	7
7	11	12	11	3
8	12	11	3	7
9	12	11	11	2
10	12	12	12	6

INITIAL ENCODING SCORES[a]: Total possible = 12.

APPENDIX K

Data for Analysis of Qualitative Differences Between Subject Groups in Information Processing

APPENDIX K-1

Retention Scores Achieved by Normal Subjects

SUBJECT NUMBER	RETENTION SCORES[a] EXPERIMENTAL CONDITIONS[b] 1	2	3	5	6	7
1	11	10	11	12	12	12
2	11	11	10	12	12	11
3	7	7	11	12	11	11
4	9	11	10	11	12	10
5	10	10	12	12	12	11
6	7	11	11	12	12	12
7	7	10	10	11	11	12
8	4	7	8	12	12	12
9	6	7	8	12	12	10
10	11	11	8	12	12	12

RETENTION SCORES[a]: Total possible = 12.

EXPERIMENTAL CONDITIONS[b]:
1 = 18 second delay + distraction
2 = 9 second delay + distraction
3 = 3 second delay + distraction
5 = 3 second delay + no distraction
6 = 9 second delay + no distraction
7 = 18 second delay + no distraction

APPENDIX K-2

Retention Scores Achieved by Right Brain-Damaged Subjects

SUBJECT NUMBER	RETENTION SCORES[a] EXPERIMENTAL CONDITIONS[b] 1	2	3	5	6	7
1	8	7	4	10	11	12
2	9	7	7	12	12	11
3	8	7	7	12	11	8
4	9	9	8	12	12	11
5	5	6	7	10	7	7
6	6	5	6	8	8	8
7	11	9	7	12	12	12
8	12	12	7	12	11	12
9	7	7	7	12	11	12
10	11	9	8	12	12	12

RETENTION SCORES[a]: Total possible = 12.

EXPERIMENTAL CONDITIONS[b]:
1 = 18 second retention interval + distractor task
2 = 9 second retention interval + distractor task
3 = 3 second retention interval + distractor task
5 = 3 second retention interval + no distractor task
6 = 9 second retention interval + no distractor task
7 = 18 second retention interval + no distractor task

APPENDIX K-3

Retention Scores Achieved by Fluent Aphasics

SUBJECT NUMBER	RETENTION SCORES[a] EXPERIMENTAL CONDITIONS[b] 1	2	3	5	6	7
1	9	5	6	8	10	8
2	9	4	5	7	9	12
3	9	7	4	8	8	10
4	6	6	4	6	6	2
5	10	10	5	12	12	10
6	5	4	6	9	7	9
7	7	6	6	10	7	9
8	6	5	1	4	4	6
9	7	5	8	9	8	9
10	10	9	7	12	11	12

RETENTION SCORES[a]: Total possible = 12.

EXPERIMENTAL CONDITIONS[b]:
1 = 18 second retention interval + distractor task
2 = 9 second retention interval + distractor task
3 = 3 second retention interval + distractor task
5 = 3 second retention interval + no distractor task
6 = 9 second retention interval + no distractor task
7 = 18 second retention interval + no distractor task

APPENDIX K-4

Retention Scores Achieved by Non-Fluent Aphasics

SUBJECT NUMBER	RETENTION SCORES[a] EXPERIMENTAL CONDITIONS[b] 1	2	3	5	6	7
1	3	5	6	4	4	5
2	1	9	2	2	6	6
3	9	6	6	12	11	9
4	7	10	7	8	9	6
5	5	7	7	11	8	7
6	6	4	3	7	5	5
7	4	4	2	1	4	5
8	5	4	7	6	7	5
9	4	1	3	2	3	3
10	5	4	5	6	5	4

RETENTION SCORES[a]: Total possible = 12.

EXPERIMENTAL CONDITIONS[b]:
1 = 18 second retention interval + distractor task
2 = 9 second retention interval + distractor task
3 = 3 second retention interval + distractor task
5 = 3 second retention interval + no distractor task
6 = 9 second retention interval + no distractor task
7 = 18 second retention interval + no distractor task

APPENDIX K-5

Retention Scores Group Comparisons

	RETENTION SCORES[a]					
	EXPERIMENTAL CONDITIONS[b]					
SUBJECT GROUP	1	2	3	5	6	7
NORMAL SUBJECTS	79	95	99	118	118	113
RIGHT BRAIN-DAMAGED SUBJECTS	68	78	85	112	107	105
FLUENT APHASIC SUBJECTS	48	54	49	59	62	55
NON-FLUENT APHASIC SUBJECTS	52	61	78	85	82	87

RETENTION SCORES[a]: Total possible = 120.

EXPERIMENTAL CONDITIONS[b]:
1 = 18 second delay + distraction
2 = 9 second delay + distraction
3 = 3 second delay + distraction
5 = 3 second delay + no distraction
6 = 9 second delay + no distraction
7 = 18 second delay + no distraction

APPENDIX L

Counting Productivity

	COUNTING PRODUCTIVITY			
SUBJECT NUMBER	NORMAL SUBJECTS	RIGHT BRAIN-DAMAGED SUBJECTS	FLUENT APHASIC SUBJECTS	NON-FLUENT APHASIC SUBJECTS
1	25	53	29	28
2	56	33	40	34
3	56	46	25	55
4	37	61	18	27
5	63	49	27	32
6	60	37	39	33
7	46	28	128	32
8	54	81	24	47
9	81	60	37	96
10	67	46	18	43

APPENDIX M

Sequence Position of Error Responses

APPENDIX M-1

Sequence Position of Error Responses: Normal Subjects

SUBJECT NUMBER	NUMBER OF ERRORS[a] ERROR POSITION INITIAL	MEDIAL	FINAL
1	1	0	3
2	0	0	5
3	3	5	6
4	4	1	4
5	1	1	3
6	2	3	3
7	3	7	2
8	6	5	6
9	0	7	10
10	3	4	3

NUMBER OF ERRORS[a]: Total possible = 28.

APPENDIX M-2

Sequence Position of Error Responses: Right Brain-Damaged Subjects

SUBJECT NUMBER	NUMBER OF ERRORS[a] ERROR POSITION INITIAL	 MEDIAL	 FINAL
1	4	5	12
2	3	4	8
3	4	7	9
4	2	3	6
5	10	7	14
6	7	11	15
7	1	2	6
8	4	1	2
9	3	7	7
10	1	5	2

NUMBER OF ERRORS[a]: Total possible = 28.

APPENDIX M-3

Sequence Position of Error Responses: Fluent Aphasic Subjects

SUBJECT NUMBER	NUMBER OF ERRORS[a] ERROR POSITION INITIAL	MEDIAL	FINAL
1	10	13	17
2	11	12	21
3	4	12	9
4	17	12	14
5	4	3	10
6	9	13	13
7	8	8	18
8	19	23	14
9	6	11	23
10	1	6	23

NUMBER OF ERRORS[a]: Total possible = 28.

APPENDIX M-4

Sequence Position of Error Responses: Non-Fluent Aphasic Subjects

SUBJECT NUMBER	NUMBER OF ERRORS[a] ERROR POSITION INITIAL	MEDIAL	FINAL
1	21	15	17
2	15	16	21
3	6	5	9
4	4	11	14
5	8	13	10
6	16	18	13
7	20	23	18
8	15	14	14
9	24	19	23
10	12	17	20

NUMBER OF ERRORS[a]: Total possible = 28.

APPENDIX N

Performance over the Course of the Test

APPENDIX N-1

Performance Over the Course of the Test: First Half- Versus Second Half-: Normal Subjects

	NUMBER OF RESPONSES[a]	
SUBJECT NUMBER	FIRST HALF-TEST	SECOND HALF-TEST
1	38	42
2	41	38
3	39	31
4	39	36
5	41	38
6	35	41
7	33	39
8	25	42
9	40	27
10	32	42

NUMBER OF RESPONSES[a]: Total possible = 84.

APPENDIX N-2

Performance Over the Course of the Test: First Half- Versus Second Half-: Right Brain-Damaged Subjects

	NUMBER OF RESPONSES[a]	
NUMBER	FIRST HALF-TEST	SECOND HALF-TEST
1	25	38
2	40	29
3	36	28
4	41	32
5	29	24
6	30	21
7	33	42
8	36	41
9	26	41
10	34	42

NUMBER OF RESPONSES[a]: Total possible = 84.

APPENDIX N-3

Performance Over the Course of the Test: First Half- Versus Second Half-: Fluent Aphasic Subjects

	NUMBER OF RESPONSES[a]	
SUBJECT NUMBER	FIRST HALF-TEST	SECOND HALF-TEST
1	23	29
2	34	21
3	25	31
4	19	20
5	40	31
6	18	30
7	32	24
8	13	16
9	32	25
10	32	41

NUMBER OF RESPONSES[a]: Total possible = 84.

APPENDIX N-4

Performance Over the Course of the Test: First Half- Versus Second Half-: Non-Fluent Aphasic Subjects

	NUMBER OF RESPONSES[a]	
SUBJECT NUMBER	FIRST HALF-TEST	SECOND HALF-TEST
1	16	15
2	15	17
3	37	27
4	29	26
5	24	29
6	17	20
7	11	12
8	22	19
9	9	9
10	18	17

NUMBER OF RESPONSES[a]: Total possible = 84.

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Leslie Janine Rothi was born on November 3, 1949, in Santa Monica, California. She resided in Westchester, California, for eleven years before moving to Rolling Hills, California. She graduated from Rolling Hills High School in June, 1967. After spending a year and a half at Los Angeles Harbor Junior College, she transferred to and in 1971 graduated from Northern Arizona University, Flagstaff, Arizona, with a Bachelor of Science degree in Speech. At California State University at Long Beach she earned a Master of Arts degree in Speech Pathology in June, 1974. She was awarded a Restricted Teaching Credential in Speech Pathology in 1973 from the Board of Education of the State of California. From September, 1973, to September, 1974, she was employed as a speech and language specialist for the ABC Unified School District, Artesia, California. She completed her Clinical Fellowship Year during that period and received a Certificate of Clinical Competence in Speech Pathology from the American Speech and Hearing Association. At that time she was also granted a Speech Pathologist License by the State of California, Board of Medical Examiners. During her doctoral program in speech pathology at the University of Florida, Gainesville, Florida, her major area of emphasis was clinical aphasiology with a split minor in linguistics and experimental psychology. Clinical and research experiences were also gained while a trainee in speech pathology at the Gainesville Veterans Administration Hospital. Certification and Licensure in Speech Pathology by the Board of Education of the State of Florida was obtained in 1978. She is a member of the American Speech and Hearing Association, International Neuropsychological Society, and the Florida Language, Speech, and Hearing Association.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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